The AUTOMATIC ELECTRIC Technical Journal

magazine devoted to progress in communication engineering

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INTRODUCING THE "JOURNAL"

OVER a ten year period, from 1932 through 1941, the *Strowger Technical Journal* presented the gradually changing panorama of communications development as seen through the eyes of the engineers of Automatic Electric Company and its affiliated companies. Interest in the Journal during those years showed that it served a most useful purpose in supplying an informal record of the principal developments of the Automatic Electric engineering staff. Its main emphasis naturally was on the field of automatic switching, although such important topics as relay design, improvements in telephone instruments, and the design of accessory apparatus were by no means neglected.

By the end of 1941, the engineers and research specialists who had been contributing articles found themselves engaged almost exclusively in vital development work—mainly in communications—for the armed services. The exigencies of the war thus made it necessary that the Journal cease publication.

With the war over, it became possible once again to concentrate attention on the needs brought about by the steadily expanding communications requirements of civilian populations throughout the world which had in the meantime become increasingly communications minded. The intervening six years have seen advances of far reaching importance in telephony, signaling and control, both electrical and electronic. The tempo of communications research has been accelerated both by wartime discoveries, and by the expanding needs of a more closely integrated society. To take advantage of those new discoveries and to meet those new needs, while preserving what is best and soundest among past developments, is the job of the engineer of today and tomorrow. Only in this way can the communications art advance continuously along the pathway toward an ever-higher standard of perfection.

In order to keep our friends informed on these developments and their application in the field, a new publication, *The Automatic Electric Technical Journal,* is being launched with this issue. Just as did the *Strowger Technical Journal* and its predecessor, *Automatic Telephone* (dating from 1913), it is hoped that the new Journal will prove a welcome addition to communications literature, and will have an enlightening and helpful influence on those concerned with and responsible for communications.

Our mailing list for this first issue has been compiled from many sources, and with the help of our affiliated companies both at home and abroad. That it is either complete or altogether accurate is probably too much to expect. The editor therefore will be glad to have errors and omissions called to his attention.

MONTEVIDEO'S CENTRAL OFFICE EXPANSION PROGRAM

By IMRE MOLNAR

SYNOPSIS: ***South America's fourth largest city schedules a 40% increase in its existing telephone plant and trunking facilities—14,600 lines using Automatic Electric equipment being added in initial phase — features of Siemens-Halske F-System previously installed — slight modifications in Automatic Electric switches permit virtually indiscriminate mixing with the European apparatus — discussion of trunking, numbering scheme and circuits — ten out of eleven offices undergoing enlargement — plans for future growth.***

MONTEVIDEO, the capital of Uruguay, has made a spectacular development in the past sixty years. It has doubled in population twice, to contain over three quarters of a million inhabitants today. World famed for such natural endowments as climate and bathing beaches, the city has not failed to expand its commerce and industry to keep pace with its growth.

The nerve center of any such bustling metropolis is its telephone system. Service in Montevideo is provided by the government owned General State Administration For Electric Utilities And Telephones, abbreviated U. T. E. in Spanish. The Montevideo network has at present ten central offices, which are enumerated below.

During the early thirties U. T. E. investigated the aspects of automatic telephone service for the city of Montevideo, and made a decision favoring step-by-step equipment. Siemens-Halske AG of Germany received contracts for ten step-by-step central offices, a toll board, and various special service features. U.T.E. inaugurated Montevideo's automatization at Centro in October, 1933, and completed the entire cutover at Carrasco in March, 1934.

The offices are classified into three types on a basis of trunking facilities (see Figure 2). *Main offices* have direct trunks between one another, as well as to their own branch offices. *Branch offices* have trunks to their respective main offices, and to their own suboffices, if any. *Suboffices* are connected with their corresponding branch offices only. The breakdown, prior to inauguration of the current expansion program, was as shown in the table in the adjoining column.

As a feature of this system, when a subscriber in a branch office lifts his receiver he immediately engages a trunk to the main office, and his dial pulses step the switches in the distant office simultaneously with the local discriminator. If the call is a local one, the trunk to the main office and the train of selectors set up there are released, and only a small amount of local equipment is held during the conversation. Similarly, when a subscriber in a suboffice originates a call he seizes a trunk from suboffice to branch office, and also one from branch to main office, so that his dial pulses step switches in three places at the same time. Of course, for a local call, branch and main office equipment is released.

Switching equipment consists of subscribers' primary and secondary lineswitches, various ranks of selectors, connectors, outgoing secondary trunk-finding lineswitches, two types of discriminators (in branch and suboffices only), three-wire to two-wire trunk circuits at the outgoing ends of inter-

	Main Offices	
Centro	12300 lines	
Cordon	8000 lines	
Aguada	5000 lines	
	Branch Offices	
Pocitos	5000 lines	branch to Cordon
Union	2000 lines	branch to Cordon
Paso	2500 lines	branch to Aguada
	Suboffices	
Carrasco	1000 lines	sub to Union
Colon	500 lines	sub to Paso
Cerro	400 lines	sub to Paso
Sgo. Vazquez	100 lines	sub to Paso

Figure 1. Aerial view of Montevideo. *(Acme Photo)*

office trunks, and corresponding incoming selectors at the other end. While most trunks operate in one direction, there are also some two-way trunks requiring both outgoing and incoming trunk circuits. Facilities were provided for 36,800 subscribers, including over 41,700 lineswitches, 13,200 Strowger switches, 2900 relay groups, and other miscellaneous equipment.

Outside line plant is in an excellent condition. Lines to subscribers have a maximum of 1000 ohms loop resistance. There is no party line service within the system, although two telephones may be connected in parallel at the subscriber's premises. Telephone instruments in service are of British and German manufacture, except for public pay stations of the local "Pinon" type.

The long distance toll board and special service positions are located in Aguada central office. Requests for toll calls from Montevideo are received at recording positions, but both outgoing and incoming connections are established by the toll operator. The regular switch train is utilized throughout for toll traffic, since all switches incorporate toll as well as local features. The operator has access to the automatic switch train through toll switching relay groups.

Expansion Plans

Montevideo's tremendous development in the past decade necessitated a large scale expansion program for its telephone facilities. U.T.E. opened negotiations early in 1944 with several manufacturers of automatic switching equipment. When it had placed the original conversion order U.T.E. was convinced of the superiority of Strowger type equipment, and years of subsequent experience fully justified this confidence. It is not surprising, therefore, that the administration wished to use step-by-step equipment for its new installations if possible. Of course, the war had so drastically curtailed the activities of Siemens-Halske AG that that company, the initial supplier, could no longer be considered as a source.

In December, 1944, U.T.E. awarded a contract to Automatic Electric Company, and thus assured itself of new equipment which would work well with the old. For, after all, there is a great similarity between Automatic Electric and Siemens-Halske apparatus in view of the common origin of the two types.

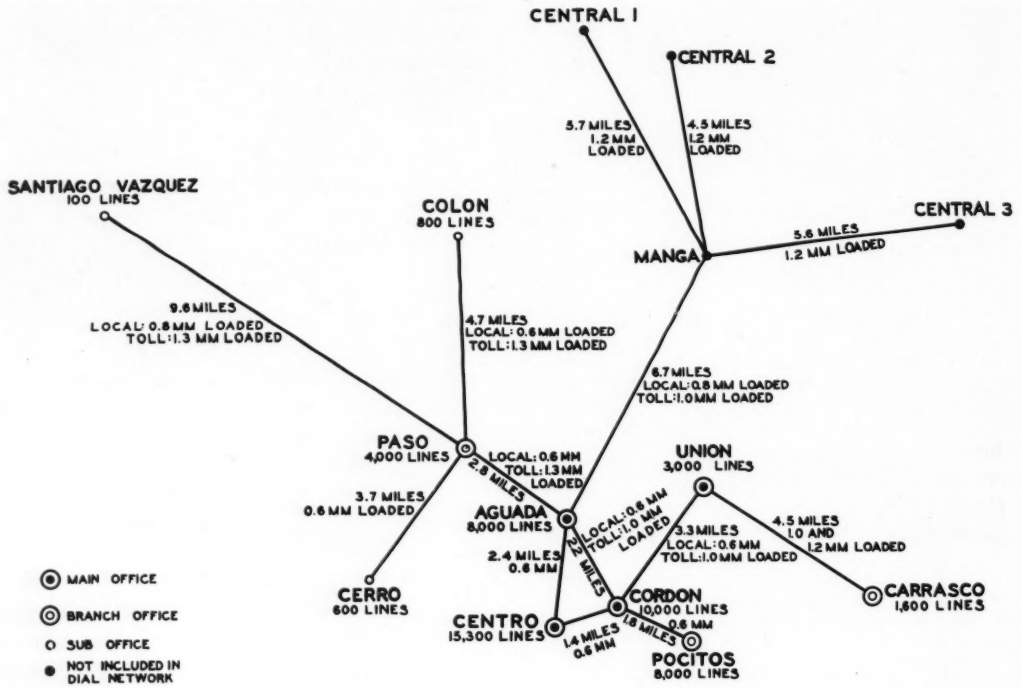
CENTRAL 1
CENTRAL 2
5.7 MILES 1.2 MM LOADED
4.5 MILES 1.2 MM LOADED
SANTIAGO VAZQUEZ 100 LINES
COLON 800 LINES
CENTRAL 3
MANGA
5.6 MILES 1.2 MM LOADED
9.6 MILES LOCAL: 0.8 MM LOADED TOLL: 1.3 MM LOADED
4.7 MILES LOCAL: 0.6 MM LOADED TOLL: 1.3 MM LOADED
6.7 MILES LOCAL: 0.8 MM LOADED TOLL: 1.0 MM LOADED
PASO 4,000 LINES
LOCAL: 0.6 MM TOLL: 1.3 MM LOADED
2.8 MILES
UNION 3,000 LINES
3.7 MILES 0.6 MM LOADED
AGUADA 8,000 LINES
LOCAL: 0.6 MM TOLL: 1.0 MM LOADED
4.5 MILES 1.0 AND 1.2 MM LOADED
3.3 MILES LOCAL: 0.6 MM TOLL: 1.0 MM LOADED
2.4 MILES 0.6 MM
1.1 MILES
CARRASCO 1,600 LINES
CERRO 600 LINES
CORDON 10,000 LINES 0.6 MM
CENTRO 15,300 LINES
1.4 MILES 0.6 MM
1.8 MILES
POCITOS 8,000 LINES
MAIN OFFICE
BRANCH OFFICE
SUB OFFICE
NOT INCLUDED IN DIAL NETWORK

Figure 2. Montevideo interoffice cable plant layout.

In 1908 Siemens-Halske began manufacturing Strowger type automatic telephone systems under license from Automatic Electric Company. In the ensuing years, naturally, each organization introduced its own modifications, both in mechanical design of switches and in control circuits. While the switches were at first almost identical, these gradual changes resulted in the familiar present-day Strowger switch of Automatic Electric Company, and the Siemens-Halske switch of 1927—considerably different in structure, appearance and mechanical details, but still with the same principle of operation. A corresponding relationship exists between the control circuits. Developed to suit the operational requirements of each company's principal customers, the circuits show considerable deviation in details, but remarkable similarity in the way they control the switch movements.

The first stage of the Montevideo expansion plan provided for an increase from 36,800 to 51,400 lines, or a growth of forty percent. No new central office was to be added, but all except one of the existing ten were to be enlarged. Cordon, Union and Carrasco offices were to have their equipment replaced entirely by a larger amount of Automatic Electric equipment; original equipment thus released would be redistributed among the other offices. It was found that this procedure would leave a deficiency in certain types of switches, and so it was decided that Pocitos office would use both existing and reinstalled Siemens-Halske equipment, and make up the balance with new Automatic Electric equipment.

In graphic form, the changes were to be as follows:

All new equipment: (Automatic Electric)

Cordon	10000 lines (formerly 8000)
Union	3000 lines (formerly 2000)
Carrasco	1600 lines (formerly 1000)

Reinstalled old equipment: (Siemens-Halske)

Centro	up to	15300	lines	(from	12300)
Aguada	up to	8000	lines	(from	2500)
Paso	up to	4000	lines	(from	2500)
Colon	up to	800	lines	(from	500)
Cerro	up to	600	lines	(from	400)

Mixed equipment: (A.E. and S-H)

Pocitos	up to	8000	lines	(from	5000)

As part of this general expansion, Union was to change from a branch to a main office, and Carrasco accordingly become a branch (to Union), instead of a suboffice. Initially, the new equipment included 14,600 line equipments, over 8300 Strowger switch units, 1500 rotary switch units, 1600 relay groups, 14,900 meters, 3 test desks and other associated apparatus.

There were three operational problems associated with this expansion program. (1) Uniform telephone service must be given throughout the city, and therefore the new equipment must provide all existing features. (2) New equipment replacing that already in use in Cordon, Union and Carrasco must work with the equipment of all the other offices in the network exactly as before. (3) Special interconnecting devices should, if possible, be avoided—particularly since in Pocitos new and old equipment would have to work side by side.

To anyone familiar with different telephone systems, these would seem difficult requirements, and U.T.E. engineers were anxious to see how they could be fulfilled. But Strowger flexibility enabled all three problems to be solved with dispatch. The first and second were merely a matter of designing suitable circuits—particularly control circuits since the Strowger equipment on both ends of interoffice trunks would have similar operating characteristics. No translating devices whatever were necessary. However, it was felt impractical to make the new equipment interchangeable on a switch basis with the old, as there were differences in mechanical design and mounting methods. But the closely related principles of operation and control permitted that any small shelf of switches could be added at any place in the system. It was thus possible not only to mix the switches as was planned at Pocitos, but also to interpose switches of either system elsewhere if desired, such as among intermediate selectors or in trunk circuits. Switches could be added to existing groups and operated in parallel on the same bank multiple. This feature was important, because it permitted an almost indiscriminate transfer of equipment within the whole network on short notice, as demanded by growth and traffic conditions. Thus, solution of the third problem made possible the most efficient exploitation of existing facilities.

To coordinate the new equipment and the old without use of interconnecting devices, Automatic Electric engineers first took their standard selector trunk hunting circuit, and applied it without any modification except to allow for the difference in exchange voltage (Siemens-Halske switches operate at sixty volts, while Automatic Electric switches normally are designed for forty-eight). They calculated the operating conditions and safety margin when switches of both types work together, and found these satisfactory from a theoretical standpoint. The engineers then conducted tests under extremely severe operating conditions, and found that the switches functioned perfectly together. As a result, the operating practices and circuit details used for years and proved with thousands of selectors could be applied to the new installations.

Interoffice Trunking Plant

The interoffice trunking plant is divided into lines used primarily for local traffic and lines used exclusively for toll purposes. As mentioned, there are direct trunks between branch offices and their suboffices, between main offices and their branches, and between main offices themselves. (Now that Union is to be a main office its trunks to other main offices will be routed physically through Cordon, although electrically the lines will be continuous, bypassing the Cordon exchange equipment.)

All interoffice trunks are high grade cable circuits. The local plant was carefully laid out to use the smallest gauge wire within the area of highest subscriber density. All cables, except those between Santiago Vazquez and Paso, and between Union and Carrasco, are of 0.6 mm wire, which is equivalent to a size between 22 and 23 AWG. Furthermore, to provide satisfactory transmission as recommended by the International Advisory Commission On Telephone Communications (the CCI), trunk cables are loaded between Paso and its three suboffices, and between Union and Carrasco. Manga office (see Figure 2), which for the time being has no automatic equipment, is also

connected by a loaded cable with Aguada, and loaded cables lead to Manga's three suboffices. The highest attenuation for an interoffice connection is that between Manga and Carrasco, amounting to 1.47 Neper, including loss inside the central offices.

Superimposed on this trunking layout are the trunks for extending toll calls to the various offices. As mentioned, the toll office is located in the Aguada building, and ordinary trunk circuits and incoming selectors reach the other main offices from there. Aguada itself, being on the same premises, is connected by simple three-conductor inside wiring. Since the CCI regulations specify a lower attenuation for trunk lines handling toll traffic, all such trunks to other main offices except Centro are grouped separately from local ones, and consist of 1 mm (18 AWG) and 1.3 mm (16 AWG) loaded conductors. Similar high grade toll trunks connect Paso with Santiago Vazquez and Colon. (This information is incorporated in Figure 2.)

Some of the distances between offices in the Montevideo area are considerable. Carrasco, for instance, is 22.5 miles from Santiago Vazquez, while the furthest suboffice to Manga is 25 miles away. These are, of course, physical distances measured along the cable route, and a better indication of factors involved is given by corresponding electrical resistances. Individual sections between two adjacent offices have a maximum of 1250 ohms loop resistance, but the highest resistance—that between Carrasco and Santiago Vazquez—amounts to 3300 ohms.

The design of automatic central office equipment must consider the highest total end-to-end resistance, since, as is pointed out later, the talking conductors on a tandem call are switched clear through without interposition of the customary impulse repeater. Hence there is no difference, as far as impulsing and switching operations are concerned, between a local and an interoffice call, and so the equipment must be designed to operate between 0 and 3300 ohms trunk loop resistance without any possibility for compensation.

Trunking in Cordon and Union

Cordon and Union, the main office and main-office-to-be which will have all Automatic Electric equipment, have a straightforward trunking layout. At present they connect the calling line to first selectors through two stages of preselectors, since the Siemens-Halske two-motion switch does not adapt itself to linefinder operation, and since such operation is only justified by large capacity finder switches. However, U.T.E. engineers appreciated the economic advantages of the linefinder system under average traffic conditions, and specified linefinders for the new installations.

Automatic Electric Company is accordingly providing these offices with 200-point Strowger linefinders, each connected through a trunk intermediate distributing frame to a first selector. The two offices have local first, second and third selectors, as well as incoming second selectors. Since, as is explained below, Cordon will have five- and six-digit subscriber numbers, there are also fourth selectors for the lines reached from the "0" level of the second selectors through third selectors.

All connectors are 100-line. There are ten connector groups in Cordon and three in Union for PBX and individual lines. Regular connector groups in Cordon have thirteen switches per hundred lines, while in Union they have twelve. Those groups with PBX lines, however, have twenty switches. Regular linefinder groups in Cordon have eighteen finders per two hundred lines, and seventeen in Union. Finder groups with PBX lines have twenty finders per group.

In accordance with the usual Siemens-Halske practice, the Montevideo offices as at present constituted have one hundred lineswitches tied to each connector group without cross-connecting facilities. The new installations also omit separate line intermediate distributing frame facilities. However, since a certain amount of flexibility for load distribution among the various linefinder groups appears desirable, the cables from the line circuits and from the connector banks are terminated on separate terminal pins on the exchange side of the main frame. This arrangement provides the equivalent of a line IDF with sufficient facilities for the expected amount of cross-connection to handle all load distribution.

All trunk groups terminated in these new offices are quite large, since they run between offices with several thousand subscribers each and with a heavy interoffice traffic. Since nothing could be gained by operating them in both directions, each trunk carries traffic one way only. Incoming trunks both from local offices and from toll at Aguada terminate

on two-wire incoming selectors. Instead of the usual trunk repeater, a small trunk circuit is inserted between selector banks and outgoing lines to convert from internal three-wire to interoffice two-wire operation.

The inside plant has been arranged to afford virtually complete access to interoffice trunking facilities. The contacts of all selector level outlets are graded in the usual manner over a number of shelves. The first two or three contacts of each group are connected directly to outgoing trunk circuits, while each of the remaining outlets terminates on the wipers of a 25-point outgoing secondary lineswitch. The banks of these lineswitches are also connected to trunk circuit groups. Since each shelf of lineswitches receives traffic from all the selector grading groups, each selector accordingly has access to any of the interoffice trunks served by secondaries, in addition to those connected directly to its own first two or three bank contacts. Individual trunks are connected to the banks of the secondaries as well, and vacant bank terminals of several secondary groups are cross-connected. The net result is that every selector has access to every outgoing trunk circuit. In other words, full availability to very large trunk groups is almost completely achieved.

However, since each selector has two or three direct outlets to trunks as first choice, it is able to seize a path most of the time without the use of secondaries, unless the traffic is heavy. Thus the movement of the secondary lineswitches is kept to a minimum.

The trunk group from Cordon to Union will serve as an illustration of this arrangement. U.T.E. specified ninety-four trunks, which the use of 25-point lineswitches permits splitting into two groups of twenty-three and two groups of twenty-four trunks each. Experience has proved maximum efficiency is achieved if two thirds of the trunks appear on the secondaries as well as being early choice direct trunks on the selector banks, while one third should be accessible through secondaries only.

There are accordingly sixty-three dual appearances (selector banks and secondaries) and thirty-one singles (secondaries only). With four shelves of secondaries, each containing twenty switches, there must be 4 (20) plus 63, or 143 outlets in all from the fifth level of the first selectors. The next step is to provide a suitable grading scheme.

The ten contacts of a selector level have access to two direct trunks, and two paths to each of the four secondary groups. Now these four secondary groups together contain all trunks to Union. Consequently, every first selector in Cordon can reach on its fifth level every trunk to Union. Similar provisions are made for trunking to other offices.

Trunking in Carrasco

Trunking arrangements in Carrasco differ from those of the two offices just described. Before the current expansion program Carrasco was a suboffice to Union, itself a branch to Cordon. Although Union is now scheduled to be a main office, its actual relation to Carrasco remains unchanged, since the latter will still be connected with the rest of Montevideo only through trunk lines to and from Union.

Union and Carrasco are reached by dialing "5" as a first digit, which seizes trunks connected to the fifth level of first selectors in any of the main exchanges. The next digit operates a second selector in Union, and, if this digit is "0", obtains an incoming third selector in Carrasco. With 1600 lines there, four digits must be dialed to reach any of them through third and fourth selectors and connectors. That is, Carrasco numbers must have six digits altogether, beginning with "50".

In considering calls originating from Carrasco it is obvious, since Carrasco has direct trunks only to Union, that these trunks must terminate on incoming first selectors in Union. On each call, therefore, the complete switch train (including the first digit) must be set up in Union just as if the call had originated there. At the same time, if the connection desired is a local one in Carrasco, a trunk to Union must not be held for the duration of the call, particularly since local conversations represent a fair share of the total traffic.

Since this type of trunking lends itself especially to switching selector operation, all first selectors in Carrasco are of this type. A trunk finder rotary switch is associated with each one, so that when a call is originated in Carrasco, an idle outgoing trunk to Union is selected at once. The first digit steps both the switching selector in Carrasco and the incoming first selector in Union. Subsequent digits likewise operate switches in pairs. The

switching selector is of the digit absorbing type, discriminating after the second digit if the call is to be a local one. In this case the trunk to Union and the switch train there are immediately released; otherwise the call is completed through the outside trunking plant to its destination. On local calls the switching selector also serves as third selector, with fourth selectors and connectors completing the train as on incoming calls. Since, as was pointed out, trunks to Union are not held during a local connection, there are less such lines than switching selectors, and this is why a trunk finder rotary switch is needed to select an idle trunk. If all trunks are engaged, local calls can nevertheless be completed. The same three-wire to two-wire trunk circuits used in other offices are associated at the outgoing end of the line. Similarly, the same type of incoming selector serves as incoming first selector at the terminating end of the line in Union. Linefinders, intermediate selectors and connectors are identical with those used elsewhere. There are twenty finders per group, and fifteen connectors per hundred lines. There is also one PBX group with twenty connectors.

Trunking in Pocitos

Somewhat similar to conditions in Carrasco are those in Pocitos. This is a branch office to Cordon, with 5000 lines at present, but to be enlarged to 8000 lines. As a branch office, Pocitos is connected only with Cordon, and as in the case of Carrasco, calls originated here engage an incoming first selector in Cordon. The digits operate switches in pairs: that is, in Pocitos and in Cordon—or at least until it has been determined whether the call is a local one or not. Pocitos also has six-digit subscriber numbers, beginning with "41", which means that calls to Pocitos are reached over trunks connected to the first level of the Cordon second selectors. The Siemens-Halske equipment at present in Pocitos is to remain there without change, and for the additional 3000 lines some of the equipment removed from the other exchanges is being reinstalled. However, since there would not be sufficient trunking apparatus available from that source, Automatic Electric equipment is being used to make up the balance.

The Siemens-Halske exchanges employ preselectors with ten outlets per line, and secondary lineswitches (with sixteen trunks to selectors) connected to each of these outlets. Branch offices such as Pocitos use a system not unlike one employing Automatic Electric switching selectors, though considerably different in details. The secondary lineswitches just mentioned have banks divided into two trunk groups, the first terminating in discriminating switches, and the second in regular selectors similar to ones used as first selectors in main offices.

When a subscriber lifts his receiver, the preselector seizes a secondary lineswitch having access to an idle discriminator. When the discriminator in turn is seized, dial tone is returned. Each discriminator is tied directly to a trunk circuit, a trunk line to the main office and an incoming first selector there, just as the one described in Carrasco. If sufficient digits determine that the call is a local one, the secondary lineswitch is "kicked" off the discriminator group and hunts for an idle selector (the third in this case) to complete the call. If the requested number should be outside of Pocitos, the discriminator and trunk are held, and no selector is engaged locally. Consequently there is not a great difference between arrangements in Carrasco and in Pocitos, though the system at the latter will not permit making a local call when the secondary lineswitch has no trunks to Cordon available on its bank. Furthermore, a local call cannot be completed if all local third selectors on the bank should be busy after the second digit is dialed. In Carrasco the switching selector, which also serves as a local third, is always available once the linefinder is seized, and local service can be given at all times as long as the necessary finders, fourth selectors and connectors are free.

Automatic Electric equipment for Pocitos consists of 230 secondary lineswitch circuits (using 25-point rotaries), 150 discriminators, 155 third selectors, and 200 fourth selectors. All these switches are being mixed in with the existing and reinstalled Siemens-Halske equipment, and the two types are to work together on a common multiple.

Numbering Scheme

From what has been said up to now the general pattern of subscriber numbers becomes apparent. Main offices as a rule have five digits, except that Cordon has both five- and six-digit numbers. All branch offices and suboffices must have six-digit numbers, because it requires two digits to determine whether a call, having a first digit of a local number, is actually a local one or goes in-

stead to a parent office or to any adjacent branch office or suboffice. The numbers in use (after expansion) are as follows:

Centro	8 00 00 to 9 59 99	
	(700 numbers omitted)	
Aguada	2 00 00 to 2 99 99	
	(21000 and 22000 omitted)	
Colon	22 00 00 to 22 07 99	
Cerro	22 10 00 to 22 15 99	
S. Vazquez	22 20 00 to 22 20 99	
Paso	22 30 00 to 22 69 99	
Cordon	4 20 00 to 4 99 99	
	and 40 00 00 to 40 19 99	
Pocitos	41 00 00 to 41 79 99	
Union	5 10 00 to 5 39 99	
Carrasco	50 00 00 to 50 15 99	

Level "6" of the first selectors is used to give the correct time to subscribers. Special services are given from the first level of second selectors in Aguada, and accordingly they begin with "21". For complaints, "211" is dialed; for information, "212"; for special information such as train, boat and plane schedules, or the weather report, "212"; for secretarial service, with information on absent subscribers, or emergency messages, "214". Requests for toll calls are made by dialing "210", but to establish the connection the toll operator calls the subscriber back over the toll switch train, just as on toll calls incoming to a Montevideo subscriber.

Forced Toll Disconnect

The Montevideo network includes a number of operating requirements not normally filled by standard Automatic Electric Company equipment. One of the most typical of these is that toll calls receive priority over local ones.* If there is a toll call to be extended to a subscriber engaged on a local connection the operator, after receiving busy tone, interrupts the conversation and requests the unwanted party to retire. Regardless of whether the latter complies with this request or not, the operator is in a position to break down the existing connection and seize the line of the subscriber called on long distance, automatically reringing him if he has already replaced his receiver. Procedure must, of course, be identical whether the desired party is calling or called on the local connection. Moreover, there can be no charge made for the interrupted local conversation in either case. Consequently, metering on all calls must be delayed until the release of the connection, so that the charge can be suppressed if the local call was disconnected by an operator in favor of a toll call.

This practice of forced toll disconnect is used by most European telephone administrations, but was not adopted in the United States or the British Commonwealth. It originated when toll line facilities were greatly limited. To increase revenues from toll circuits these administrations were anxious to eliminate as much delay as possible in setting up a toll call. In line with this policy a local conversation was interrupted at once when a toll call came in for either party. The value of this practice is now all but lost, since toll circuits have become plentiful to a degree that service can be given while the calling subscriber is still on the line.

In manual systems forced toll disconnect can be accomplished very simply by bringing in the line multiple through break jacks on toll switching "B" positions. Inserting a plug then detaches the complete local multiple. When designing their automatic telephone systems, European manufacturers such as Siemens-Halske incorporated a similar feature in their toll connectors. The use of "last party release" connectors is desirable, since otherwise the party previously called on the local connection would pick up a new linefinder after being disconnected in favor of a toll call to the former calling subscriber.

Other Siemens-Halske Features

Connectors are arranged to provide an alarm if they are held for an undue length of time without both parties being on the line. Such a condition may arise when the calling party does not replace the handset after receiving busy tone or ring back tone for a prolonged period, or if either party holds the connector after the other has retired.

The normal ringing period in the Siemens-Halske system is ten seconds: that is, ringing current is extended to the called line for one second every ten seconds. Since a uniform practice must be maintained in all Montevideo offices, the same ringing cycle is used for the Automatic Electric equipment. A ten-second maximum waiting period to signal the called party after the connection is established is, however, somewhat long: accordingly, a short splash of ring is sent out immediately after the last digit is completed and the line seized. Ringing current is connected on one side to negative battery, and this battery is also applied on the

generator supply leads to the connectors during the silent period while ringing current is absent.

The tone signals given by the Siemens-Halske system are somewhat different from those of Automatic Electric Company, but the new equipment conforms with the provisions of the existing offices. Dial tone has a frequency of 450 cycles, and is interrupted as follows: ¼ second tone, ¼ second silent, ¾ second tone, ¾ second silent. The busy signal is a steady 150-cycle tone. The ring back tone is derived by feeding a portion of the ringing current back through a small condenser to the calling subscriber. To improve the audibility of the ringing current, which is a smooth 23½-cycle sine wave, a small amount of 450-cycle ripple is superimposed on the main ringing generator feed. The interruptions of the ring back tone are, of course, the same as those of ringing: one second tone, nine seconds silent, with a short splash immediately after the connection is established. In addition to these customary tones, a 150-cycle signal, interrupted 120 times a minute, is connected to vacant or changed number line terminals. On calling such a line, a subscriber hears this signal during the silent period of the ring back tone.

It has already been mentioned that the equipment operates on 60-volt direct current. Allowance must be made for a ten percent variation in voltage, although automatic charge control equipment as a rule keeps fluctuations within much narrower limits. However, the possibility of opposite extremes in voltage in different offices during an interoffice connection must be taken into consideration. Transmitters are operated on a low current supply through the 500 + 500 ohms feeding bridge.

Subscriber lines are all equipped with message registers. These are actuated at the termination of a successful call by superposition of a 65-volt booster battery on the regular 60-volt exchange supply.

Peg count meters are connected to various switch shelves, and step each time a switch is engaged. Overflow meters register each occasion when calls are delayed because no idle linefinders are available.

Each switch is equipped with an individual resistor, to which ground is connected during the period when the switch is occupied by a call. By connecting these resistors of a group of switches in parallel, the current through this combination will be proportional at all times to the number of switches occupied. This current is made to actuate a watt-hour meter, the reading of which is consequently proportional to the total telephone traffic through the group of switches under observation during any arbitrary period.

One test connector is furnished to afford access for remote control testing of all lines and line circuits associated with each group of a hundred subscribers. Test distributors provide access to these connectors from test desks. Selector switches are arranged for routiner access, so that when a routiner is added all selectors, connectors and lines can be routine tested automatically. In the meantime, simple test sets are furnished for manual routining of the equipment. Linefinders are arranged for automatic routine testing in groups of two hundred lines.

Circuit Details: Metering Procedure

Since the Montevideo installation includes a number of circuit features new to those readers who are familiar with the usual Automatic Electric system for large city networks, a few of these will be discussed in detail. The diagram associated with these descriptions includes only those elements necessary for the understanding of the unusual features, other details being omitted for the sake of clarity. Vertical or rotary movement is not described, since it is achieved throughout in the customary manner.

In Figure 3 the calling telephone is connected through a linefinder to the impulse repeating and battery feed relay *A* of the first selector. This relay is held in an operated position from ground in the selector, through a low resistance winding of relay *N*, to the line cut-off relay *CO*. The first selector, several intermediate selectors, and the connector are actuated from dial pulses, repeated by relay *A*, until the called line is reached. It is immaterial whether the connection stays in the local office or extends through several interoffice trunks, since all such trunks consist of clear metallic conductors, and there is nothing interposed between the condensers of the first selector and relay *A*.

It should be noted that pulse repeating from the first selector is the reverse of standard Automatic Electric practice. Since ground is extended on the

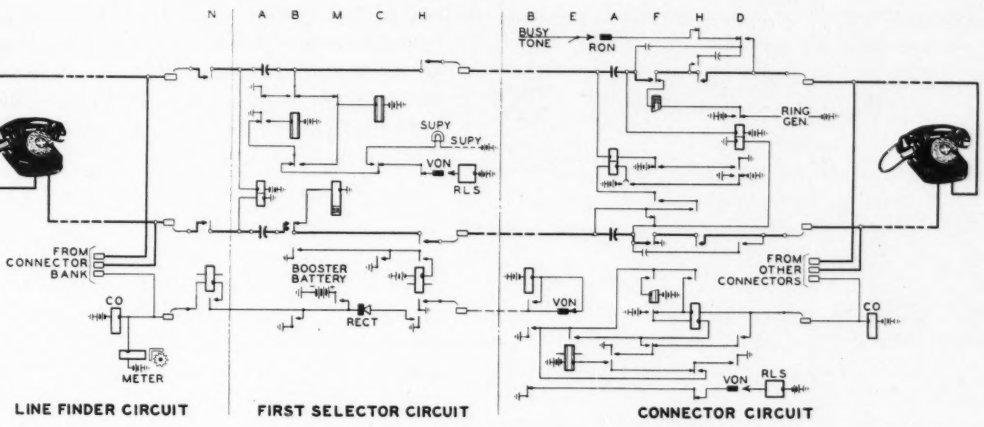

Figure 3. Local calling circuit (simplified).

—conductor from the back contact or relay *A* at each opening of the dial, the *A* relays of the intermediate selectors and connector operate each time the dial is interrupted, while normally they stay unoperated.

When the called line is reached, relay *H* operates and generator is extended to the called telephone. Relay *H* is held through a series low resistance winding to the line cut-off relay of the called party, exactly in the way the linefinder acts on the opposite end of the connection. When the called party answers, relay *F* operates, locks, and disconnects ringing. Relay *D* supplies transmission battery to the called subscriber.

When the calling party disconnects, relays *A* and *B* in the first selector restore. Relay *C*, however, operates during the slow release period of *B*, preventing relay *H* from restoring. The lower winding of relay *A* in the connector is joined to battery, and relay *M* operates from this, extending positive booster battery over the *C* leads toward the meter of the calling subscriber. This meter is adjusted so as not to operate on regular 60-volt supply, but will readily do so with an additional sixty-five volts from a booster battery. The linefinder relay *N* is held after the restoration of *B* from ground on relay *H* in the first selector. The rectifier protects the booster battery potential from being short circuited by this ground. Relay *C* restores after a short delay, removing the holding circuit from *H*. All selectors, the linefinder, and relay *B* in the connector release, but other relays of the latter remain operated through a make contact on relay *D* as long as the called subscriber is still on the line. This feature is usually meant when "last party release" connector is mentioned. Naturally, the connector cannot be reseized during this period because the circuit to relay *B* remains open until the switch mechanism restores to normal.

Metering must not take place, of course, if the called party was busy, if he did not answer, or if the call was not completed for some other reason. In these cases, tracing the circuit shows that the battery through the lower winding of *D* is not present on the —trunk, being open at the *H* or *F* contacts. During disconnect relay *M* of the first selector, therefore, cannot operate, and the entire switch train restores upon release of the first selector relay *C* without applying metering potential towards the calling line.

Toll Connection Circuits

It should be of interest to consider a toll connection which is to be extended to a Montevideo subscriber. The operator inserts the calling plug into a jack associated with an idle toll switching trunk, and dials the subscriber's number. The connection is built up by using an incoming selector (except for Aguada), several intermediate selectors,

and a connector. The switches are identical with those used for local traffic. If the called line is not busy, the establishment of the call is the same in all respects as a local one.

When the called subscriber answers, battery is removed by relay *F* from the —trunk, and ground is placed under control of relay *D*. As long as the called party is on the line, ground is extended to the toll switching trunk relay group, thus extinguishing the cord supervisory lamp. If, however, the called party replaces his receiver and opens the loop, ground is removed, and the supervisory lamp lights. The connector relay *A* is held operated from battery in the toll switching trunk circuit relay group over the —trunk conductor. Springs on *A* place a multiple ground holding circuit on relay *H*, which prevents the forced disconnect of this toll connection by another toll operator attempting to reach the same local party (see below). At the conclusion of the toll call the operator withdraws the plug, removing ground from relay *B*. The switch train restores, except for the connector, which remains under the control of the called party. The process of release is the same, regardless of whether the lower winding of relay *A* is connected to battery or to springs of relay *D*, as in the case of holding connectors. There is nothing corresponding to the first selector relays *C* and *M* in the toll switching trunk circuit, and release is entirely under the operator's control.

If, however, a local conversation is in progress (with the connection established through linefinder, selectors, and connector, as previously described), and a toll call comes in for the called subscriber on the local connection, the toll operator proceeds to set up a connection as outlined above, using another connector of the group to which the called subscriber belongs—in all respects identical with the one shown in Figure 3. The operator, however, receives busy tone, since relay *H* could not operate because it found a low resistance ground on the *C* wiper. She then extends battery over the + trunk, operating relay *D* through its lower winding. The open talking circuits are now bridged through make contacts on the *D* relays and condensers to the wipers, and the operator may request the parties of the local conversation to disconnect in favor of the toll call. The operator is also in a position to enforce this request by placing ground on the —trunk and holding relay *D* operated at the same time. Direct ground is now extended to the *C* wiper through make contacts of relays *A* and *D*. This ground shunts down the low resistance holding winding of relay *H* in the connector used by the local call. The parties are effectively disconnected, the calling subscriber receiving busy tone, while the *CO* relay of the called subscriber remains operated.

When the operator removes battery and ground from the toll switching trunks,, relays *A* and *D* restore, and relay *H* of the connector used by her can now operate. If the called subscriber has hung up, automatic ringing takes place, and operations are subsequently the same as if the called party had not been busy at all. If, however, the subscriber is still on the line, relay *F* is immediately operated, ringing is disconnected, and the line is switched to the *D* relay. Subsequent procedure is as previously described. The called line can be resignalled at any time by placing ringing generator on the trunk from the operator's position circuit. Naturally, the calling party should not be charged for the call which was prematurely and forcibly terminated. Since relay *H* of the connector used in that call restored and opened its make contacts, the battery through the lower winding of *A* is no longer present on the —trunk, and metering, just as in the case of a call to a busy line, cannot take place.

Quite similar is the procedure followed when a toll call is made to a subscriber who is the calling party on a local connection. In this case, the toll train terminates in a connector associated with the calling party, while the latter is connected with the local call through a linefinder. The operator receives a busy signal, requests that the conversation be terminated, and disconnects as in the previous case. When ground is applied to the *C* wiper of the operator's connector through contacts of relays *A* and *D*, relay *N* in the linefinder circuit is shunted down, opening up the loop to the first selector. Upon the release of the latter the whole switch train, with the exception of the connector, restores. The connector, being of the "last party release" type, stays operated as long as the called party of the local connection stays on the line. Since the local call cannot, of course, be charged to the calling party (the recipient of the toll connection), the extension of metering potential is effectively prevented by opening the linefinder *C*

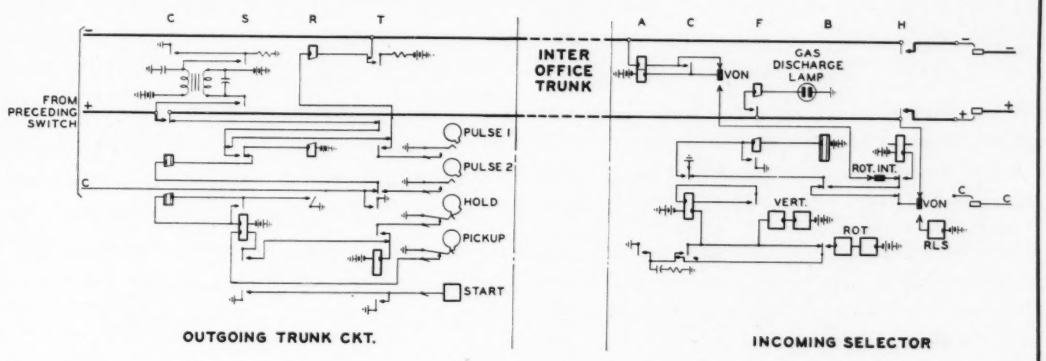

Figure 4. Interoffice trunking circuit (simplified).

conductor to the *CO* relay and meter. The *CO* relay is held from the toll train connector, and its relay *H* operates just as in the last case.

It has already been pointed out that it is not possible to interrupt an existing toll connection, because its relay *H* is held through its second winding and the make contacts of the operated relay *A*. Shunting down of the series holding winding of *H* therefore has no effect.

Interoffice Switching Circuits

It has been stated frequently that there are no trunk repeaters employed in the Montevideo network, but that all trunk conductors are switched straight through from end to end. The circuits used to permit such operation are somewhat unusual and should be considered in detail. Figure 4 represents the circuits employed on both ends of an interoffice two-wire trunk, operated in one direction only. Details irrevelant to this discussion have been omitted. Figures 5 and 6 show, respectively, a photograph of an incoming selector and one of an outgoing trunk relay group.

A selector preceding this outgoing trunk circuit steps by finding battery through the windings of relays *C* and *R* in series. *R* is in its operated position at all times while the trunk is idle and the incoming selector is available at the distant end. *R* remains energized all through the call from ground on the *C* lead and relay *C* in series. The latter extends the + trunk conductors from the preceding selector bank to the interoffice line. The selector in the meantime has also completed its switching operation, and everything is ready for the continuation of the connection.

However, an unusual condition now exists. While the outgoing trunk circuit, as well as the trunk line, are seized and effectively prevented against intrusion from another call by ground on the *C* lead, the incoming selector is not aware of this condition and remains in its normal state until the beginning of the next digit. This is represented by a series of ground pulses on the —conductor to relay *A*, which repeats them to the vertical magnet of the incoming selector. At the same time relay *C* of the same switch operates from the first pulse of the series. It opens the rotary and release circuits, and operates relays *B* and *F* in series. *C* is very fast to operate, but slow to release after its lower winding is shorted by springs on *F*. After this series of pulses *C* restores and the circuit to the rotary magnet is completed. Relay *A* now serves as interrupter for the rotary magnet. When the incoming selector finds an idle bank contact, relay *H* operates and the rotary action ceases. The talking conductors are extended to the —and + switch wipers. In examining the circuit now, it will be noted that these line wires are switched straight through free from all attachments, except the upper winding of relay *F* through the gas discharge lamp to ground. However, since the lamp is de-ionized at this time and therefore non-conducting, there is no electrical circuit through this path. The same condition exists on all calls, re-

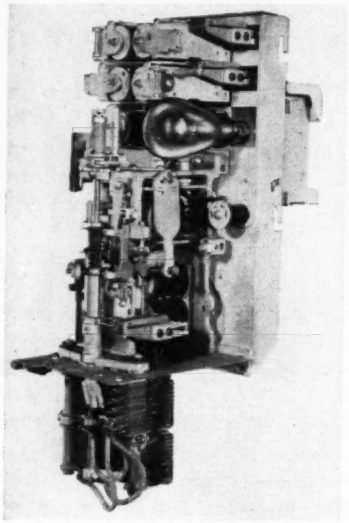

Figure 5. Incoming selector.

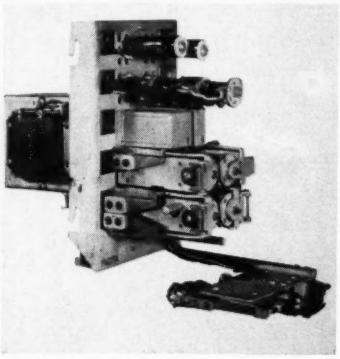

Figure 6. Outgoing trunk relay group.

gardless of their origin and destination: whether remaining in a local office or switched through several interoffice trunks like the one just described. The calling subscriber's bridge in the first selector and the other one in the connector are tied together by a pair of metallic conductors free of attachments, irrespective of whether they are twenty feet or twenty miles apart.

At the conclusion of the call, ground is removed from the *C* lead of the outgoing trunk circuit on the left side of the diagram. Relay *R* restores immediately, but the release of *C* is somewhat delayed because of its copper sleeve. This delay is further extended by the circuit through the now restored springs of *R* and relays *C* and *S* in series. *S* operates and shorts out the holding winding of *C*. Current flows through the primary winding of the transformer while both *C* and *S* are up. The sudden application of current induces a high voltage by step-up action in the secondary winding of the transformer. This same voltage now appears on the + trunk conductor. It is sufficient to ionize the gas in the discharge lamp, and current is sustained from battery on the transformer secondary through the —line, the upper winding of relay *F*, and lamp to ground. Because of this current, the field in relay *F* is in opposition to that of the local circuit, so that it restores. Relay *B* restores as a result, opening the path through the lamp, which now extinguishes. Relay *H* restores, opening the wiper circuit, and the circuit of the selector release magnet is now complete.

In the meantime relay *C* of the outgoing trunk circuit has restored and removed the transformer secondary from the + line. The primary is also opened, but in two steps, as a precaution against damage from the high voltage induced by the sudden collapse of the field; and for the time being the current is only reduced by a series resistor in the primary circuit.

When the incoming selector has completely restored to its normal condition, a circuit is completed from ground through the springs of *C, B, H,* the vertical off normal assembly, the + line, the springs of *C, T,* and the operated *S* relay to the lower winding of *R* and battery. *R* operates and opens relay *S,* which releases. The holding circuit of *R* is now complete through its upper high resistance winding across the trunk, both line conductors, to battery at the *A* relay, and ground as before. The transformer current now is also completely interrupted. The circuits at both ends of

the line, being in their normal condition, are ready for the next call.

If for any reason the release was incomplete—because of mechanical trouble, for example, or failure of the gas discharge lamp, or because the line was open—the above described circuit is also incomplete; relay *R* cannot operate and *S* cannot restore. While under such conditions the trunk is properly guarded against new seizure, it is advisable to make another attempt for release. The operated relay *S* causes a timer circuit to start and to extend certain ground pulses to the trunk circuit in trouble. The first one to arrive is the "pick-up" pulse of short duration, which causes relay *T* to operate and to lock to ground on the *Hold* lead. The condition of the circuit at this time is the same as when it is idle and ready to receive a call, although, naturally, ground from *T* contacts on the *C* lead prevent the circuit from being seized by a selector. Ground from "pulse 2" operates relays *S* and *R* in series, and the status of the circuit is now that of being occupied by a call. Pulses "1" and "2" slightly overlap to insure the continuity of operation of *R*. When ground is removed from the "pulse 2" lead, *R* and *S* release in that order and in between a high voltage flash is transmitted over the + trunk, as was described for the regular procedure. If the incoming selector responds this time and conditions are restored to normal, the timer action is concluded and the trunk becomes available for new calls. Otherwise, the cycle is repeated about once every ten seconds until it is successful, or if this cannot be accomplished an individual and general alarm is given by a prolonged seizure of the timer circuit over the start lead.

When a connection is built up over several interoffice trunks, it is expected that each of them will release in sequence, and each outgoing trunk circuit will furnish the release pulse to its associated incoming selector. In practice, however, the procedure is considerably simplified, since normally the pulse generated in the originating office has ample power to restore the *F* relays in all incoming selectors at once.

Expansion in Action

The first step in the expansion program was the replacement of the thousand lines of Siemens-Halske equipment in Carrasco by 1600 lines of Automatic Electric manufacture. Since nothing else was changed at that time, the first thousand lines of the new equipment were substituted for the corresponding old ones (400000-400999) while the additional 600 lines were given the numbers 409000-409599. The switching selectors in Carrasco can only determine after the third digit whether the call is a local one or one intended for Union. In the former case the trunk is released and the call completed in one of the two groups of fourth selectors and connectors. Incoming calls to Carrasco were handled temporarily through levels *9* and *0* of the Union third selectors. There were, therefore, two groups of trunks to Carrasco, and two groups of temporary incoming fourth selectors. Additional outgoing trunk circuits were installed at Union to take care of this traffic. The traffic originated in Carrasco by the first thousand lines was handled in Union, as before; but that of the 600 new subscribers was temporarily routed directly to Cordon, where a sufficient number of incoming first selectors were provided for this purpose. There was no change in the numbering scheme or in method of operation, since, as will be recollected, all calls originated in Carrasco automatically seize an incoming first selector in Cordon via switching repeaters in Union. The only deviations introduced for these 600 lines were the omission of the switching repeaters in Union, and the fact that their calls to Union were completed via Cordon, instead of directly.

A few months after cutting Carrasco into service the replacement of Union with new equipment was completed. Since Union became a main office, with direct trunks to all like exchanges, and its numbering scheme changed to five digits starting with *5*, it was then necessary to introduce a corresponding numbering change in Carrasco. The digit *5* replaced the *4* used there previously as the first digit, and *1* instead of *9* became the third digit of the new 600 lines: in other words, numbering in Carrasco now runs from 500000 to 501599. The switching selector in Carrasco discriminates and releases the trunk, in case of a local call, after the second digit and acts as a local third selector. Calls are completed through fourth selector and connector as before. The switching selectors and other equipment work without modification. A few straps have to be removed before the new equipment in Cordon is cut into service. Incoming calls to Carrasco are routed through the *0* level of Union second selectors, a single group of trunks, and levels

0 and *1* of incoming third selectors in Carrasco, to the fourth selectors and connectors. All calls originated in Carrasco now terminate on incoming first selectors in Union; those in Cordon are no longer required.

Cordon is the next office to be changed. This is planned in two steps: 8000 lines of new equipment will replace a like number of existing ones; another 2000 lines will be added when the old equipment has been removed.

Simultaneously with the Cordon installation, 3000 lines will be added to Pocitos. They will include Siemens-Halske equipment removed from Union and Carrasco plus new switches manufactured by Automatic Electric Company to take care of deficiency in selectors and trunking facilities.

When Pocitos and Cordon have been cut over, the first phase of the work will be completed. The second phase will consist of the redistribution of the 8000 lines of Siemens-Halske equipment from Cordon, and whatever is left from Union and Carrasco, among Centro, Aguada, Paso, Colon and Cerro.

But this is by no means the end of U.T.E.'s program. New plans now call for subsequent additions of 3000 lines to Cordon, 1200 lines to Union, 800 lines to Carrasco, and four small new offices, one with 500 lines and three with fifty each. Hence it may truly be said that Montevideo's telephone system is keeping pace with its own phenomenal development.

A "DIRECTOR" NETWORK IN A VENEZUELAN OIL FIELD*

By G. C. PLASMIER

***SYNOPSIS:** Intercommunication requirements of the Mene Grande Oil Company and Creole Petroleum Corporation's six operational headquarters—need for a uniform numbering scheme—how Automatic Electric "Directors" translate a two-digit office code and a three-digit call number into impulse sequences permitting direct dialing between all stations in the system—incorporation of service discrimination feature — the Director's operation analyzer.*

THOSE of us who are accustomed to driving an automobile into a gasoline station and asking the attendant to fill the tank seldom stop to think of the manifold operations within the oil industry that must precede the stage where the refined product is made available for consumption. Among these are the surveying of oil basins, the drilling of wells, the construction of pumping stations, the installation of pipelines, the various processes of refining, and the transportation of many types of final products.

All these activities must be closely coordinated. To perform such work in some of the newer oil fields which are located in primitive and relatively inaccessible regions is a complex and ponderous task, calling for every possible use of modern equipment and labor-saving and time-saving methods. It can readily be understood what a vital part modern telephone communication plays in such an enterprise.

One such project that is currently making history is represented by the combined operations of the Mene Grande Oil Company and the Creole Petroleum Corporation in the Eastern Venezuela Oilpool. Here the oil companies' activities are scattered over a wide area, with six different operational headquarters in strategic locations. The two extreme centers of development, for example, are approximately 270 miles apart.

Modern communication facilities knit together the various operational and administrative activities of the oil companies. This article recounts how Strowger Automatic telephone equipment, especially the Strowger "Director," has been able to meet the exacting service requirements of this project on a sound and practical engineering basis.

A Strowger Automatic telephone switchboard is installed in each of the six operating headquarters to serve the telephone needs of the community area. The nature of the oil companies' operations, however, is such that it also requires speedy intercommunication between these six centers of development. Each of the six automatic switchboards is accordingly a part of a six-office automatic network, with facilities for establishing connections to any telephone in any office.

Figure 1 shows the approximate geographic relationship of the six automatic offices, together with distances between them. In a public telephone system, calls over such distances would be subject to toll charges, and would normally be handled by toll operators. This long distance network, however, is owned and operated by the petroleum organizations, and was built and is maintained on a fully automatic basis for their sole benefit. No charges are therefore made for calls between offices, though use of long distance circuits involves certain restrictions, for reasons which will be explained later.

Interoffice Dialing Problems

The six telephone offices are trunk-connected in tandem as shown in Figure 1. In such a network, establishing a connection between two lines terminating in the same office presents no special engineering problem, since only sufficient digits need be dialed to connect the calling and called lines. In this case three digits would suffice, because each office has less than 1000 lines. Under straightforward step-by-step operation, establishing a connection between lines terminating in adjacent offices

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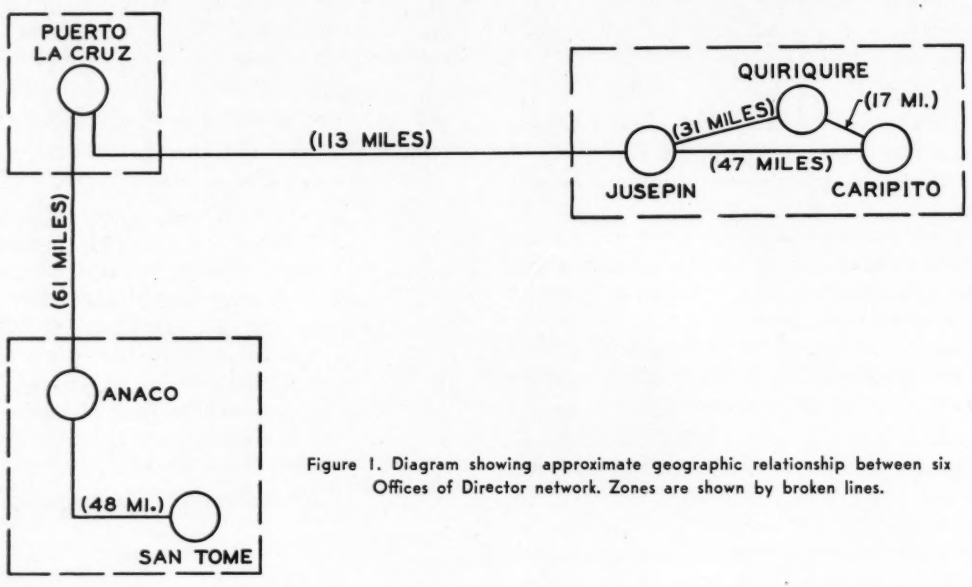

Figure 1. Diagram showing approximate geographic relationship between six Offices of Director network. Zones are shown by broken lines.

presents no special problem, either, although a four-digit number would be required. As the number of tandem offices increases, however, the number of digits needed to complete a call between the most widely separated pair of offices must also increase. Thus, a call between the "end" offices of a five-office tandem group would require a seven-digit call number, four digits of which would be used to route the call through the intermediate offices.

People who are constantly located in the same office area would encounter no difficulty, since the number of digits to be dialed to reach any given station anywhere in the network would always be the same. However, operating personnel traveling over the entire property would have to make use of special dialing instructions for each call made, as the number of digits to be dialed to reach a given station would vary depending on the call's point of origin.

Obviously, in a network of this kind where calls are freely dialed between offices and where the nature of the business requires extensive field operations, it would be simpler if, to reach any given station, users in all offices could dial the same call number. This simplicity of universal numbering is illustrated in the ordinary multi-office city telephone network where the call number for any station is the same no matter who telephones or from which office he calls.

Numbering Scheme: Translation

In a city network, universal numbering is usually made possible by having direct trunks between all offices. The network in Figure 1 however, does not lend itself economically to this method of trunking due to the great distances between offices. Another method must consequently be employed, involving the use of facilities that will allow universal numbering and at the same time direct a call to its destination regardless of the number of intermediate switching points required to extend the connection.

Such facilities are afforded through the use of the Strowger Automatic Director in this network. The essential function of the Director is to *register* the digits dialed by the person making the call, and to *translate* that portion of the call number which represents the "office code" into the particular digit or combination of digits needed to extend the connection to the terminating office. The digits repre-

senting that portion of the call number which relates to the particular station or line in the terminating office are then retransmitted in their original dialed order and value.

Physically, the Director is a simple assembly of relays and stepping switches of the same standard types used for other switching functions in a Strowger Automatic exchange, and therefore involves no new or untried mechanisms. It is only another and simplified version of the Director originally designed to solve the complex trunking problems inherent in large metropolitan telephone systems, such as the London, England, network.

Network Zones

The oil companies' telephone network is divided into three zones, with each zone harboring all the activities for a given area. San Tome and Anaco constitute one zone; Quiriquire, Caripito and Jusepin constitute a second zone. Puerto La Cruz, which is the Caribbean pipeline terminal for both these districts, constitutes the third zone.

All offices except Puerto La Cruz are equipped with Strowger Directors. The physical location of Puerto La Cruz in the network, and the choice of office prefixes, make it possible to dispense with Directors in this office. (Puerto La Cruz is located midway between the other two zones, and with the present network telephone calls originated in this office need never be relayed through more than one tandem office. Should, however, additional offices be added at the extreme ends of the network at a later date, then Directors will also be installed at Puerto La Cruz. No modifications of existing equipment will be required at that time, as the Directors will merely be inserted in the present switch train.)

Office Code Numbers

A five-digit numbering system is employed. The first digit determines the zone for which the call is intended. The second digit selects the office in that zone, while the final three digits select the individual line in that office. The actual number and variety of digits transmitted by the Director to complete a call, however, varies according to the office from which the call was originated and the office to which the call is destined. Each of the six offices in the network has a two-digit office code number, as follows: *65* for San Tome, *66* for Anaco, *77* for Jusepin, *78* for Quiriquire, *79* for Caripito, and *81* for Puerto La Cruz. The offices forming a zone employ the same first digit as part of the office code number. It should be noted that the second digit of the two-digit office code number is different for each of the six offices. That digit is the first to be received by the Director, as shown in the condensed trunking diagram in Figure 2.

The second digit of the office code actually indicates to the Director which terminating office is desired. This digit is translated by the Director into one or more other digits, as required to reach the incoming trunk equipment in the terminating office. The translations of this second digit made by the Director on calls between various pairs of offices are shown in Figure 3.

To illustrate the effect of translation, let us consider a call from Quiriquire to San Tome. The first two digits of all San Tome call numbers are *65*. Dialing of the first digit operates a local first selector at Quiriquire, and extends the connection to a local second selector and a Director in the same office. The Director accepts the second digit, *5*, and translates it into the sequence of digits *1665*, which route the call through Jusepin, Puerto La Cruz and Anaco, and then to an incoming selector at San Tome. This routing may be followed by reference to Figure 2. The remaining three digits of the call number are sent by the Director without change, and serve to operate the local switches in San Tome to complete the connection to the called station. After the Director has completed its function it is disconnected, and is then available for use on other calls.

The digit or digits sent out by the Director are chosen to correspond with selector levels available in the various offices for selecting trunks to adjacent offices. This permits maximum use of the selector equipment. In case of future growth, changes can be made as required if the selector level used by the Director for routing the call is to be utilized for other services.

The versatility of the equipment is further illustrated by its ability to make the pulses delivered by the Director agree with those delivered by the dial under control of the calling party. On calls originated in Puerto La Cruz the various selector switches respond to the actual pulses corresponding to the office code dialed. The Directors transmit

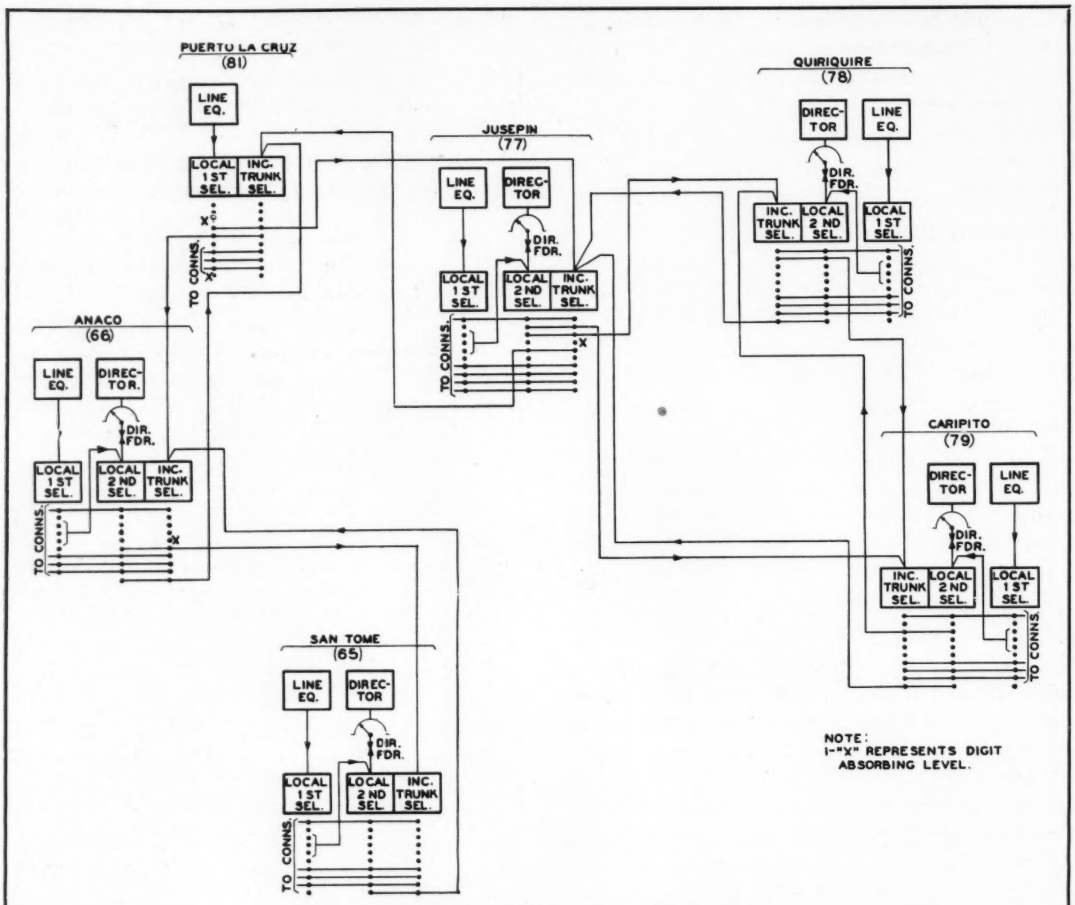

Figure 2. Condensed trunking diagram of network.

these same pulses when routing a call through Puerto La Cruz.

Only those digits that are required to establish a trunk connection to the terminating office are newly created by the Director. The final three digits of the five-digit directory number are stored in the Director until after it has completed the transmission of the routing digits, and are then retransmitted by the Director in the same sequence and with the same value they had when dialed.

Director Code Capacity

The Directors for this installation are capable of transmitting a total of five routing digits to reach the terminating office, and have facilities for transmitting a total of ten different routing codes: i.e., the Director is designed to handle calls to a total of ten different offices. Cross-connecting facilities are incorporated in each Director, so that by the simple process of changing wiring on a small terminal strip the Director can be made to translate any office code it receives to any of ten groups of numbers, each group consisting of any number of digits from one to five.

As previously mentioned, the office code numbers are selected to permit the equipment in Puerto La Cruz to complete all calls to the proper zone, and the desired office in that zone, on a regular step-by-step basis without Directors. This can readily be understood from a study of Figure 2.

For example, when a telephone call is both originated and intended for completion in Puerto La Cruz, the first two figures (representing the office code) are absorbed by the local first selector. Similarly, when a call is intended for completion in an adjacent office, the second digit of the office code number is absorbed in the terminating office.

Interoffice Call Restrictions

The oil lands served by this network are for the most part located in uncharted regions of the country, and the oil companies are pioneers in introducing to these sparsely settled areas some of the modern conveniences of civilization. Due to the nature of the country and the distances between telephone offices, construction costs for long distance networks are high; hence it is essential to limit the total number of circuits between offices to an economical figure. Therefore, only such calls as are "necessary" are permitted between offices.

To restrict the interoffice telephone traffic to essential needs, only a limited number of operating personnel of the oil companies who have business in all the areas are permitted to make telephone calls to any point in the system. The activities of certain other personnel extend only to the zones in which they are located. Still others have duties that are confined to the particular office in which they are operating. This results in three different classifications of service: unlimited, semi-restricted, and local.

In view of the absence of operators, compliance with restrictions must be enforced automatically, and not left to personal judgment or individual discretion. This policing of the calls is a further function of the Strowger Director. If the telephone call is from an "unlimited" station, the Director gives such a call the "go ahead" signal and routes it to its final destination unhampered. Should, however, a call intended for completion in another office be attempted from a telephone limited to local service, the Director halts the progress of the call and relays it to an individual designated to answer all "irregular" telephone calls. Similarly, semi-restricted stations are prevented from reaching other zones to which they are not entitled to make calls. (The requirements in Puerto La Cruz, where there are no Directors, are simpler. Only two classifications, unlimited and local, are provided, through the well known methods used in standard private Automatic branch exchanges.)

FROM \ TO	SAN TOME (65)	ANACO (66)	PUERTO LA CRUZ (81)	JUSEPIN (77)	QUIRIQUIRE (78)	CARIPITO (79)
SAN TOME (65)	–	1	11	117	1178	1179
ANACO (66)	5	–	1	17	178	179
* PUERTO LA CRUZ (81)	65	66	–	77	78	79
JUSEPIN (77)	665	66	6	–	8	9
QUIRIQUIRE (78)	1665	166	16	1	–	9
CARIPITO (79)	1665	166	16	1	8	–

Figure 3. Chart showing scheme of digit translation provided by the Directors. (*Note: Puerto La Cruz office is not equipped with Directors, and therefore digits transmitted from that office—on calls originating there—are the actual digits dialed).

Those of the operating personnel who are constantly located in the same district, and who have occasion to call only stations served from their own telephone office, are encouraged to signal such stations by dialing only the last three digits of the five-digit directory number. Such a call by-passes the Directors, thereby leaving them available for interoffice calls. When only the last three digits are dialed, the call is routed to the connector switches directly from the banks of the local first selector switches. It should be noted, however, that only local telephone calls, originated and terminated in the same office, can be completed by dialing this abbreviated number.

The chief functions of the Director in this network are to assist in extending the call to its final destination, and to test the line on which the call originates for the classification of service entitled. After it has accomplished these functions the Director is released. Since the Director is actually in use just in the originating office and just during the process of establishing a call, only a few Directors are needed in each office.

Equipment Supervision

The Director used for this installation is shown in Figure 4, which gives an idea of the simplicity of this "electrical robot". It is recognized, of course

that the need for faultless operation is paramount The functioning of any of the Directors can be placed under instant surveillance by its almost human operation analyzer. Simply manipulating a key or a dial displays the entire operation of the Director on a small instrument panel permanently associated with each group. This panel shows by means of lamps the number of pulses transmitted, and by means of a meter their speed and quality.

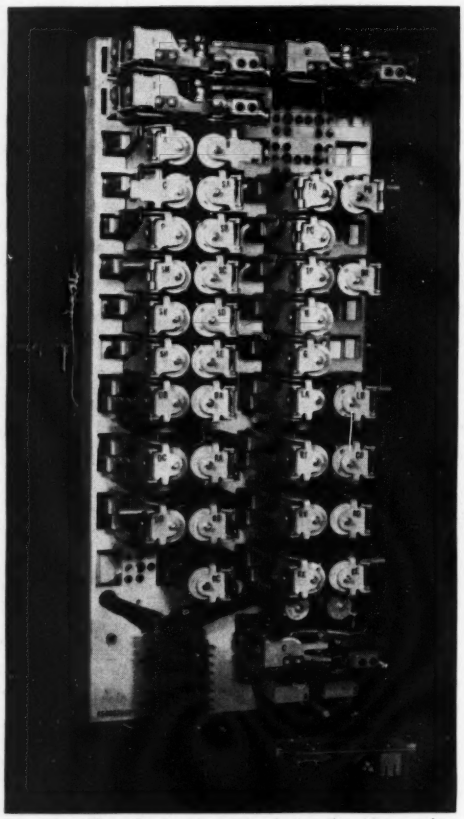

Figure 4. The Director as used in the Venezuelan network.

As a result, a skilled technician is not required to analyze the operation of the Director.

The six offices range in size from 200 to 400 lines. The automatic switching equipment in each office, except for the Directors, is very much the same as in any other step-by-step office. It consists of line equipment, selector switches and connector switches, these last including both the regular individual line type and the PBX (trunk-hunting) type. Some of the offices also include a group of special party line connectors to serve temporary field lines during preliminary construction work in a new district.

It will be seen from the foregoing discussion that this network is a novel one in many ways. Telephone calls may be dialed over the entire area without the aid of a telephone operator in any of the six offices. An outlet to the commercial telephone company is afforded from a PBX connector group in one of the offices. Information service is provided by the local telephone plant department of the combined oil company enterprise. All six of the offices are designed for unattended operation. Any functional irregularity of the Automatic telephone equipment is automatically transmitted to a designated individual in each of the offices. This person can, by dialing certain test numbers, determine the nature of the irregularity to ascertain whether it requires immediate attention or can be deferred.

This installation may be compared to a miniature city telephone network. The principal distinguishing feature is that in a city network the various offices, besides being larger, are in a comparatively compact area with direct trunks between most of the offices. In this system the offices are widely separated, with most of them connected in tandem. Thus, the network is truly a preview of what the Director can accomplish in a commercial telephone toll network with extensive tandem trunking.

INTERCONNECTION BETWEEN STROWGER AND ROTARY EQUIPMENT

By N. SALVESEN

SYNOPSIS: *Comparison of Strowger and Rotary automatic systems—methods of pulse control — use of translators and selector-registers—paralleling connector scheme—features of two typical interconnections; a new Strowger office as satellite to a Rotary main office, and a Strowger addition to an existing Rotary office.*

AUTOMATIC Electric Company's engineers have from time to time evolved methods of interconnection between Strowger automatic equipment and I. T. & T.'s Rotary type automatic equipment. These plans of interconnection have concerned both installation of new Strowger offices in exchange areas served by Rotary type equipment and the addition of Strowger equipment to existing Rotary offices for increased line facilities. In all cases, it has been possible to work out plans permitting practical methods of interconnection.

Rotary and Strowger systems differ in several fundamental respects. In the Strowger system the switches are of the two-motion type, in which a vertical movement steps the wipers to a desired level and a horizontal movement rotates the wipers in on that level. The switches are self-driven, and operate directly from the subscriber's dial impulses. The Rotary system, on the other hand, is of the uni-directional, motor-driven, register-translator type. A register receives impulses from the subscriber's dial, and, by revertive impulse control, directs the Rotary switches to the desired terminals. In the case of interconnection, this fundamentally different method of pulse control requires the use of registering and translating equipment for routing calls between the two systems.

On calls from Rotary to Strowger, translators are needed to provide revertive pulses back to the registers in the Rotary system, and translate these revertive pulses into decimal pulses corresponding with those sent out by the dial. These translated pulses then operate the Strowger switches in successive steps to the terminals of the called station. The entire dialed number is not stored in the translator, but each digit as soon as received is translated and immediately delivered directly to the Strowger switches.

Calls from Strowger to Rotary are routed over Strowger switches in which the group selectors preceding the connectors are of the "selector-register" type. From the banks of these selector-registers trunks run to the connectors in the Rotary equipment, which are used for extending the final loop to the called station in the Rotary system. Each selector-register is provided with a 2-digit register in which the last two digits of the called number are stored and translated into revertive pulses for moving the Rotary connectors to the terminals of the called station.

An alternative to the selector-register method of operation on Strowger to Rotary calls is to install Strowger type connectors with their banks multipled to the banks of the Rotary connectors. In this case, standard Strowger selectors are used in place of the selector-registers. Translation is not necessary, since calls from Strowger to Rotary subscribers are not routed over the Rotary connectors but over the paralleling Strowger connectors.

The paralleling connector scheme considerably simplifies Strowger to Rotary interconnection in that it eliminates storing and translating, and permits all calls originated by Strowger subscribers to be completed on a straightforward Strowger basis. The application of this plan, however, depends to a large extent upon economical factors and operating plans, particularly as they relate to future developments and the retiring of old equipment.

Strowger to Strowger calls are in all cases completed entirely over Strowger type switches, without the use of register and translating equipment, thus

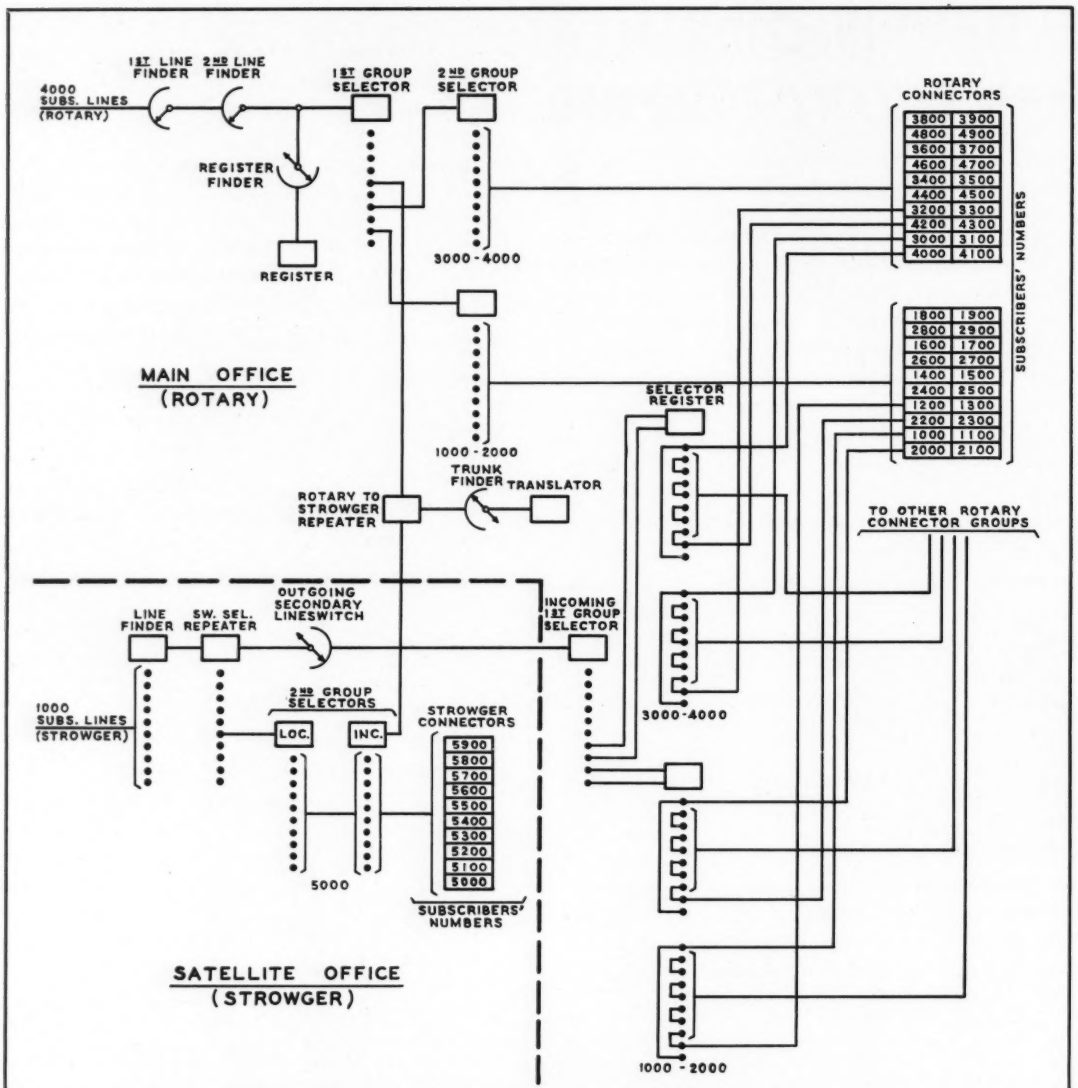

Figure 1. Strowger 1,000-line office as satellite to Rotary 4,000-line office.

ensuring to these calls the speedier operation inherent in systems where switches operate directly from the subscriber's dial.

The problems of interconnecting Strowger and Rotary equipments invariably involve conditions that are individual to the particular office, or exchange area, under consideration. These conditions generally concern subscribers' numbering plans, trunking arrangements, digit capacity of existing registers, and the type of Rotary equipment used. However, since the underlying principles of interconnection are usually the same, this article will confine itself to two typical problems: (1) the installation of a Strowger satellite office to function with a Rotary main office, and (2) the installation of a Strowger addition to an existing Rotary office. (Since provision of extra toll and special service equipment presents no problem

altering plans for interconnection, this subject is omitted from the discussion.)

Strowger Office as Satellite to Rotary Main Office

Figure 1 shows diagrammatically a plan for installing a new 1000-line Strowger office as a satellite of a 4000-line Rotary main office.

The subscribers' directory numbers will consist of four digits. The numbers in the Rotary office will run from 1000 to 4999, while the numbers in the Strowger office will run from 5000 to 5999.

The equipment in the Strowger satellite office will consist essentially of Strowger linefinders, switching selector-repeaters and associated outgoing secondary lineswitches, second group selectors and connectors. In the Rotary office there will be installed Strowger equipment including outgoing Rotary to Strowger repeaters, trunk finders, translators, incoming first group selectors and selector-registers.

Since the Strowger office is a satellite of the Rotary office, switching selector-repeaters, switching on the first digit, will be used as first group selectors. The switching selector-repeaters will be trunked via outgoing secondary lineswitches to incoming first group selectors in the Rotary office. The outgoing secondary lineswitches effect a more efficient use of the trunks, and thereby reduce the number of interoffice trunks required.

The second group selectors in the Strowger satellite office, as well as the Strowger incoming first group selectors in the Rotary office, are of the standard 10-level, ten-trunks-per-level type.

The selector-registers in the Rotary office are of the 20-level type, but for the sake of clarity the twenty levels should rather be considered as two sets of 10-level banks, a lower set and an upper set. Associated with each two sets of banks are a lower and an upper set of wipers, mounted on a switch shaft capable of making ten vertical steps. The wipers are so located on the shaft that when it is moved vertically (say) four steps, the lower wipers will be opposite the fourth level of the lower set of banks and the upper wipers will be opposite the fourth level of the upper set of banks. The trunks from the lower bank levels of the selector-registers are run to Rotary connectors serving the odd thousand of a 2000-line group, while the trunks from the upper bank levels are run to Rotary connectors serving the even thousand. The selector-registers are provided with two entrance paths from the incoming first group selector levels. One path is for the odd thousand and the other path for the even thousand. Thus the first digit dialed, in addition to picking a selector-register, also causes the selector-register to determine the odd or even thousand of the Rotary equipment, and to connect the calling line to either the lower or upper set of wipers (as determined by the dialed digit).

The Rotary connectors are of the 200-line type. These connectors have 10-level banks with twenty sets of terminals per level, thus providing terminals for a total of two hundred lines. The lines are arranged on the banks in two groups of one hundred lines each, one even numbered, the other odd numbered. The even numbered group uses terminals 1-10 of each level and the odd numbered group terminals 11-20 of the same level. Therefore, in order to reach a desired terminal in the odd numbered group, ten additional impulses are required to rotate the brushes past the set of ten terminals associated with the even numbered group. To reach (say) terminal *4* of a given level in the even numbered group only four pulses are required, while to reach terminal *4* in the odd numbered group fourteen pulses are required.

A call from a Strowger station to Rotary station *2364* is about to be made. When the subscriber originates the call, both a switching selector-repeater in the satellite office and an incoming first group selector in the Rotary office are seized. In response to the first digit dialed, *2*, both of these switches step in unison to the second level.

Since the selected level, *2*, corresponds to the first digit of a subscriber's directory number terminating in the Rotary office, the switching selector-repeater in the satellite office operates only as a repeater, and the incoming first selector in the Rotary office rotates its wipers in on the dialed level and selects a trunk to an idle selector-register in the 1000-2000 group.

When the selector-register was seized, the calling line was connected through to the upper set of wipers, since the seizure of the selector-register from the second level of the preceding selector denotes that the called number is in the even thousand.

The second digit dialed, *3*, causes the selector-register to step its wipers to the third level and

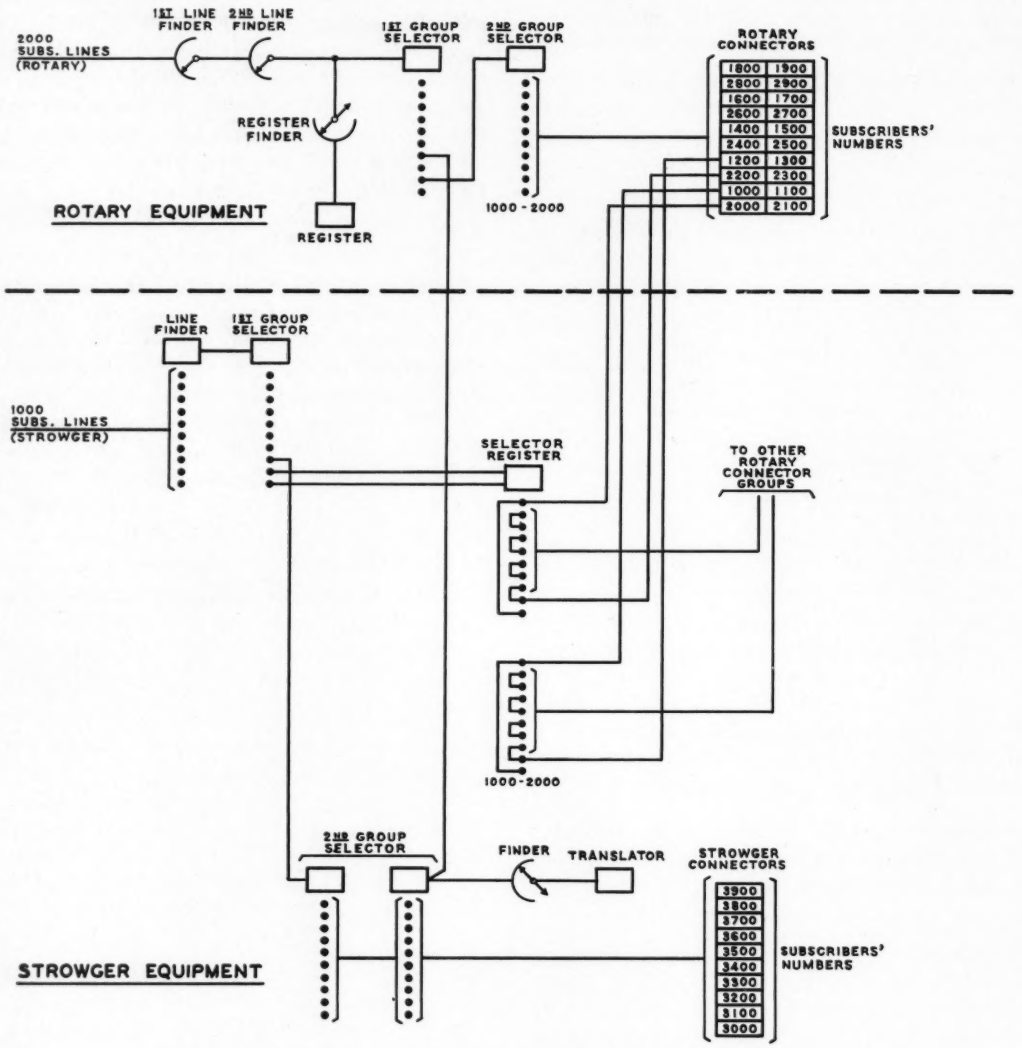

Figure 2. Strowger 1,000-line addition to Rotary 2,000-line office.

automatically rotate in on that level. Since the calling line was connected through to the upper set of wipers, the selector-register therefore selects a trunk to an idle Rotary connector in the 2200-2300 connector group. Furthermore, the digit *3* denotes that the wanted number is in the odd numbered group of the 2200-2300, 200-line connector group.

The third and fourth digits dialed, *64*, are stored in the register equipment of the selector-register. These two digits, controlled by conditions set up in the selector-register when the second digit *(3)* was dialed, are translated into revertive pulses and sent out for operating the Rotary system connector to terminal *64* in the 2300 connector group, thus completing connection to station *2364*.

As is customary, if the called station is idle, it is rung automatically. If the called station is busy, or if all-paths-busy is encountered, the calling party receives busy tone.

A subscriber in the Rotary exchange now is calling a subscriber at number *5426,* in the Strowger satellite office. The four series of impulses from the dial are received and stored in the Rotary office register in the usual manner. Under control of the register, and as determined by the first digit, *5,* of the called number, the first group selector in the Rotary office operates to select a trunk to an idle second group selector in the Strowger office, via the Rotary to Strowger trunk repeaters. The seizure of the repeater causes an idle translator to be connected temporarily to the trunk repeater, through the trunk finder.

The translator sends revertive pulses back to the register in the Rotary system. These revertive pulses clear out the register, moving into the translator the digits previously stored in the register. These digits, which correspond to the second, third and fourth digits, *426,* of the dialed number, are translated into proper decimal pulses and sent out by the translators for operating the Strowger switches.

In the usual Strowger manner, these decimal pulses operate the second group selector to the fourth level and select a trunk to an idle connector in the 5400 group. They then operate the connector to terminal *26,* thus completing the connection to station *5426.* The translators are released and made available for other calls as soon as the last digit has been transmitted.

The trunk finders may be of either the single motion Rotary type or the two-motion Strowger type, depending upon which will better suit each particular project.

A call is now made from one Strowger station to another having the directory listing of *5324.* When the subscriber originates the call, both a switching selector-repeater in the satellite office and an incoming first group selector in the Rotary office are seized. In response to the first digit dialed, *5,* both the switching selector-repeater in the satellite office and the incoming first group selector in the Rotary office step in unison to the fifth level.

Since the selected level, *5,* corresponds to the first digit of a satellite office subscriber's directory number, the trunk to the Rotary office is immediately disconnected, and the switching selector-repeater rotates its wipers in on the fifth level, selecting a trunk to an idle second group selector in the satellite office. The dialing of the remaining three digits, *324,* successively operates the second group selector to the third level, selects a trunk to an idle connector in the 5300 group, and then operates the connector to terminal *24,* to complete the connection to station *5324.*

While the Strowger office in the plan shown in Figure 1 is a satellite office of a Rotary main office, it could just as well be a main office having standard first group selectors instead of the switching selector-repeaters, and having trunks from a level of the first group selectors to incoming second group selectors in the Rotary office. The subscribers' directory numbers in this case would consist of five digits, and the incoming first group selectors in the Rotary office would become incoming second group selectors. Otherwise, the general scheme of interconnection would remain about the same as shown in Figure 1.

Strowger Equipment Expanding a Rotary Central Office

Figure 2 shows diagrammatically a plan for the installation of an additional thousand lines to an existing 2000-line Rotary office in a single office area.

The subscribers' directory numbers will run from 1000 to 2999 for the Rotary subscribers, and 3000 to 3999 for the Strowger subscribers.

The Strowger equipment will consist essentially of Strowger linefinders, first and second group selectors, connectors and selector-registers, with the addition of translators and associated finders for routing Rotary to Strowger calls.

A call takes place from a subscriber, connected to Strowger equipment, to a subscriber at station *2364,* which uses Rotary equipment. The first digit dialed, *2,* causes the first group selector to step its wipers to the second level and automatically rotate in on that level, selecting a trunk to an idle selector-register.

Dialing the last three digits, *364,* operates the selector-register and the Rotary type connector exactly as described for a similar call in connection with Figure 1.

Rotary to Strowger calls and Strowger to Strowger calls are completed as described for similar calls

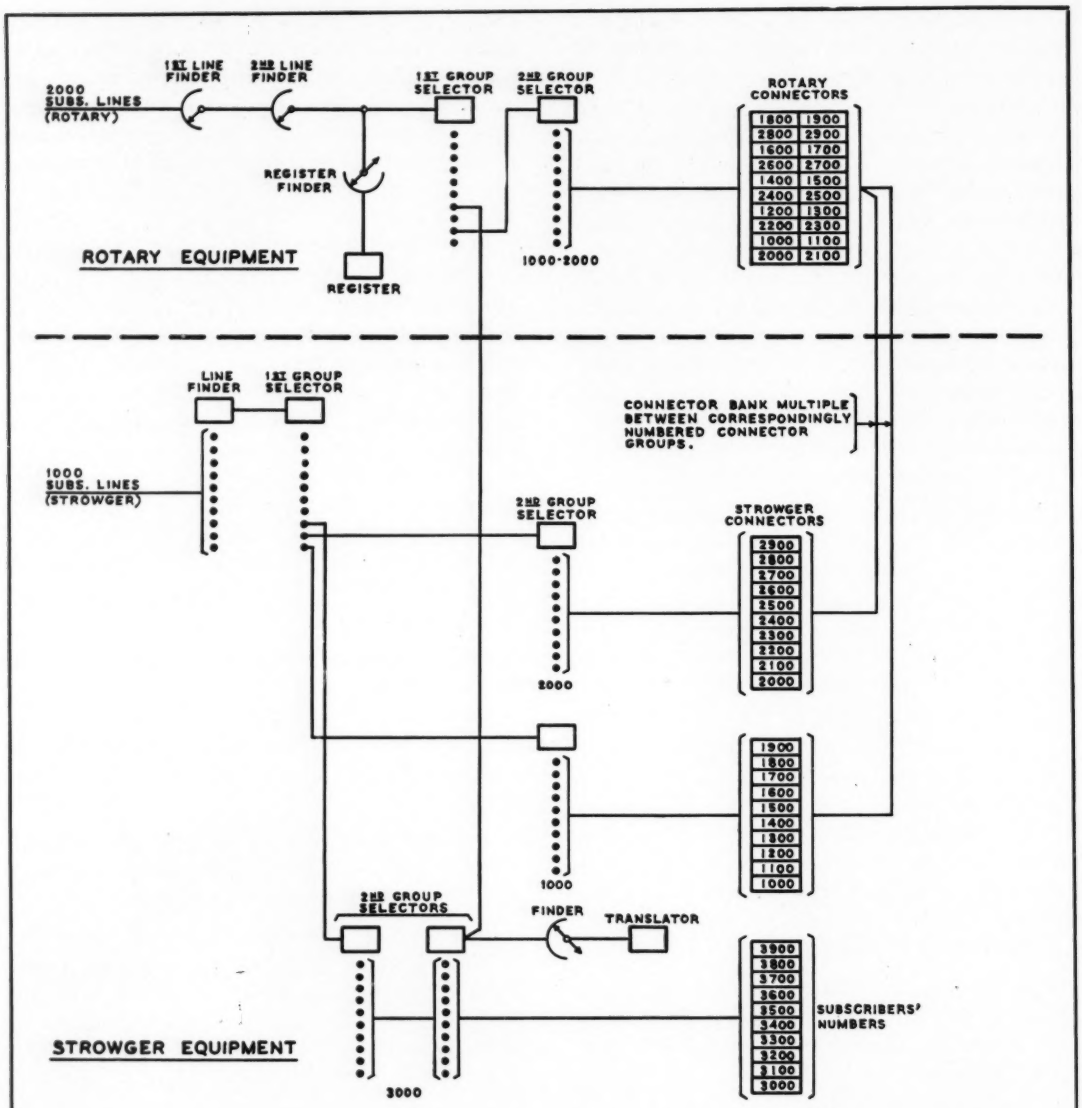

Figure 3. Strowger connector groups paralleling Rotary connector groups as part of replacement program (same office as in Figure 2).

in connection with Figure 1, and need, therefore, no further explanation.

When the equipment in an existing Rotary office, either as a whole or in part, has nearly reached the end of its useful life, and serious consideration is given to its eventual replacement by modern Strowger equipment, this replacement may, if desired, be accomplished readily on a gradual conversion basis. Strowger additions of suitable sizes may be made from time to time, thus gradually retiring worn out Rotary equipment. In such cases it would undoubtedly be most economical to install Strowger connector groups, paralleling the Rotary connector groups. Figure 3 shows diagrammatically

such an installation as applied to the plan shown in Figure 2. The Strowger switches would be of standard type, since no registering and translation would be required on Strowger to Rotary calls. The paralleling connector groups would fit in with the final conversion program, permitting its completion without interference with service and without changes in subscribers' directory numbers. Thus the initial Strowger installation would form the nucleus of an eventual complete Strowger office.

In the plan shown in Figure 3, the banks of the Strowger type connectors are multipled to the banks of correspondingly numbered hundred groups in the Rotary connector groups. The 20-level Rotary selector-registers have been replaced by standard Strowger 10-level selectors. Second group selectors for the 1000 and 2000 groups, and connectors for the paralleling Strowger connector groups, are provided in quantities sufficient for handling Strowger to Rotary traffic. All calls originated by Strowger subscribers are by this method completed entirely over standard Strowger switches.

From the above outline it will be seen that Automatic Electric Strowger equipment and circuits afford simple, convenient and effective possibilities of expansion for Rotary installations. For those calls completed entirely over the Strowger additions there is the added advantage of speedier operation stemming from direct impulsing and control by the subscriber's dial.

PURDUE UNIVERSITY'S PRIVATE AUTOMATIC BRANCH EXCHANGE

By H. C. JONES

SYNOPSIS: ***A leading educational institution modernizes its communication facilities—local calls, automatic and manual—incoming and outgoing city calls, including toll messages and intercept feature—conversation timing and night blocking of dormitory calls — multi-party and dormitory lines — numbering scheme — other special features; code paging units, watchman's service equipment, and conference facilities.***

THE private automatic branch exchange (P-A-B-X) at Purdue University, Lafayette, Indiana, affords an excellent example of the way in which the complex service requirements of a university can be met by versatile modern telephone equipment. These requirements are probably typical of the needs of many colleges throughout the country and abroad. For this reason it is thought worth while to discuss the details of this installation, keeping in mind the fact that similar applications may be made at other universities.

The centralized P-A-B-X serves the entire university: its administration buildings, structures associated with the various colleges, gymnasiums, field house, men's and women's residence halls, the Union Building, and other establishments. This P-A-B-X replaces numerous private branch exchanges and private automatic exchanges. The various PBX's each had separate trunks to the Lafayette central office without means of direct connection between them for local university calls. Calls between PBX's therefore needlessly utilized two central office trunks. Some complications existed in calling university personnel, moreover, since it was necessary for anyone telephoning to know through which PBX he could reach the desired party. These difficulties were overcome by the use of the centralized P-A-B-X to serve the entire university, with only one group of trunks to the central office.

The P-A-B-X is in a sense more like a sub-office of Lafayette than a P-A-B-X as it is ordinarily conceived, since all university automatic stations have direct access to all Lafayette subscribers, and, conversely, all Lafayette subscribers have direct access to all Purdue automatic stations, without the assistance of an operator. It is only necessary to prefix the proper code to dial between Lafayette and Purdue.

The installation consists of 580 automatic lines, 220 common battery manual lines, 800 connector terminals, a four-position attendant's cabinet (including one watchman's service position), watchman's service equipment for five 25-station routes, and five code call units.

Facilities Provided

The equipment is arranged to provide the following classes of service:

1. Individual lines
2. PBX lines
3. Two- and four-party lines
4. Multi-party lines (max. twenty)
5. Watchman's service lines
6. Common battery manual lines

Special service features include:

1. Conversation timing
2. Night blocking of dormitory calls
3. Multi-party dormitory lines
4. Intercepting of incoming city calls
5. Code call
6. Watchman's service
7. "Meet me" conference
8. Intercepting of vacant and changed numbers.

Linefinder Equipment

Two types of linefinders have been provided. A 100-point linefinder includes facilities for watchman's service lines, and a 200-point linefinder for permanent and conversation timing. All watchman's service stations are accordingly assigned in

the 100-line group, while all dormitory lines requiring conversation timing are assigned in the 200-line group. Lines other than the watchman's service and dormitory lines may be assigned in either the 100-point or 200-point linefinder groups.

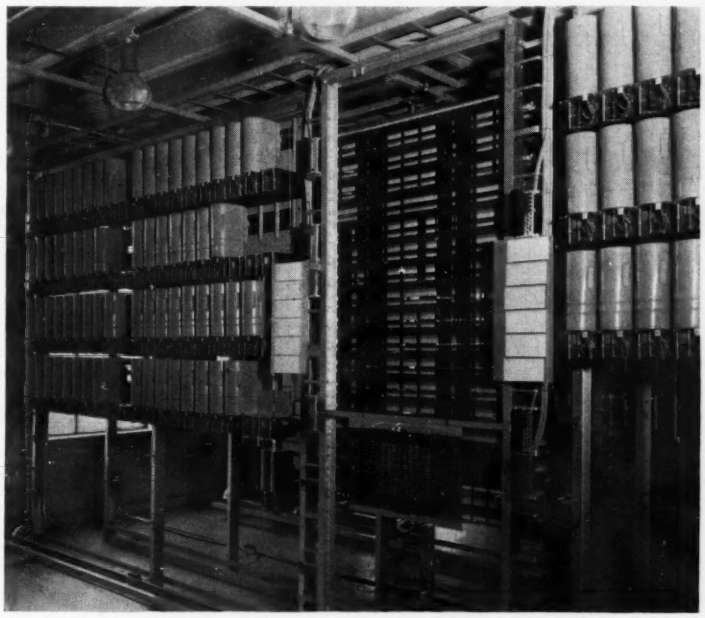

Figure 1. Automatic equipment racks.

Connector Equipment

Various types of connector equipment are provided for various classes of service. Individual and watchman's service lines may be assigned in any connector group. Three groups of "trunk hunting" connectors have been provided to serve individual and PBX trunk groups or consecutively numbered lines of ten trunks per group or less. One group of "trunk and level hunting" connectors has been provided to serve PBX trunk groups of more than 10 trunks per group or less. One 5-party, 200-line connector group has been provided for individual, two-party, four-party or five-party lines, although it is not anticipated that more than four-party service will be provided in this group. These lines are for dormitory and staff individual line service, and for private room party line service. Two twenty-party, 100-line connector groups have been provided for individual and multi-party service. These lines are mainly for the purpose of providing service to the dormitories, where as many as twenty students are served by one line. These lines also serve certain professors, using a single telephone instrument, whose calls are differentiated by a one- or two-ring code.

Common Battery Lines

The Union Building is served by common battery lines. These run from telephones in approximately one hundred hotel rooms of the Union Building where manual service is desirable. The Purdue attendant maintains a complete listing of the guests and provides standard hotel telephone service. The common battery lines are ordinarily handled on a strictly manual basis, with calls originated and received via the Purdue attendant. If desired, however, the attendant may operate a "dial through" key which permits the guest to dial the number wanted himself.

A few of the common battery lines are multipled to connector terminals so that incoming calls may use the switch train. These lines are for certain university officials who wish to have the assistance of the operator in originating calls. Incoming calls reach them either manually or automatically.

Local Calls

Local calls between automatic stations are completed by direct dialing through the local switch train without assistance of the attendant.

Local calls between automatic and manual stations are completed via the Purdue attendant. A person at an automatic station calling a manual station dials *1* for the attendant and requests the

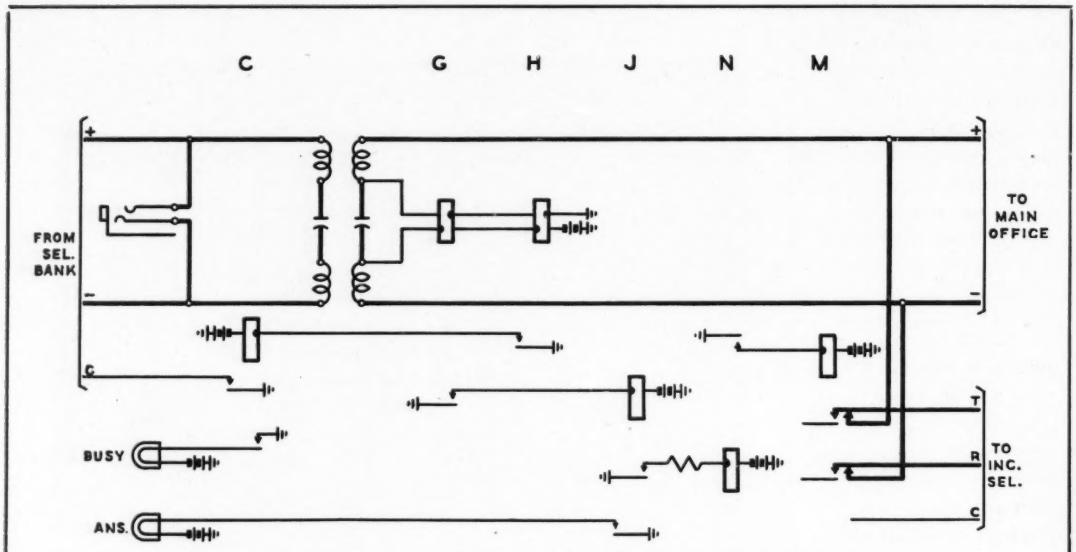

Figure 2. Two-way central office trunk, Purdue University P-A-B-X.

desired manual station number. A person at a manual station calling an automatic station signals the attendant by removing the receiver from the switch hook. The attendant plugs into a jack *OGT to P-A-X*, which is a circuit to a local automatic line equipment. She then either dials the desired number or operates the "dial through" key and instructs the calling party to dial.

City Calls

All Purdue automatic stations can call subscribers in the city exchange by prefixing the digit *0* to the city subscribers' directory listed numbers. The calls are thus routed over two-way trunks to incoming first selectors in the Lafayette central office, and thence over the central office switch train to the desired stations. Purdue manual stations reach city subscribers via the Purdue attendant.

Incoming calls from the city can be completed by Lafayette subscribers, if the call is for a Purdue automatic station, by prefixing *92* to the Purdue station number. If the call is for a manual station, the code *90* is dialed to signal the Purdue attendant, who completes the call as in manual practice.

Incoming calls from the city to P-A-B-X stations or to the Purdue attendant are handled over the same trunks. This is made possible by the use of a bi-level repeater in the Lafayette central office. This repeater may be reached from two different levels of the second selector, depending upon whether the call is to the attendant (Code *90*) or to a P-A-B-X station (Code *92*). If the bi-level repeater is reached from one level (level *2*) a loop is closed to the trunk circuit at Purdue, and when reached from the other level (level *0*) ground is immediately placed on the negative trunk before the loop is closed.

On calls to a P-A-B-X station a loop is closed to the trunk circuit to relays *G* and *H*, as shown in Figure 2. Since relay *G* is differentially connected it will not operate, and only relay *H* functions. Relay *H* closes a circuit to relay *C*. Relay *C* operating lights the busy lamp, and grounds the *C* lead back to the selector bank to busy the trunk for outgoing calls. The loop also is extended to the incoming selector which when seized prepares the way for further dialing.

On calls to the Purdue attendant, ground is extended over the negative trunk before the loop is closed. This ground causes relays *G* and *H* in the central office repeater to operate. Relay *G* operating closes ground to relay *J*. Relay *J* operating closes ground through 500 ohms to relay *N*,

and closes ground to the answer lamp. Relay *N* operating closes ground to relay *M*. Relay *M* operating then opens the + and — leads to the *T* and *R* leads, to prevent the incoming selector from being seized. Relay *H* operating closes ground to relay *C*. Relay *C* operating lights the busy lamp, and grounds the *C* lead back to the selector bank to busy the trunks for outgoing calls.

Toll Calls

All outgoing toll calls are handled on a delayed basis. Consequently, anyone desiring to make a toll call should signal the attendant, by dialing the digit *1* in the case of automatic stations, or by removing the receiver from the switch hook in the case of manual lines. The attendant receives the information regarding the individual desired, the calling person's name and station number, and any other pertinent facts. The Purdue attendant then dismisses the person calling, and plugs into a special trunk group *OGT to Toll and Special Services*, dialing *110* for the Bell toll operator. After supplying the toll call information she retires from the circuit. When the desired toll connection has been set up, the toll operator dials a Purdue automatic station by adding the prefix *92* to the station number, or signals the Purdue attendant by dialing *90* if the call originated from a manual station.

Incoming toll calls to Purdue stations are completed over one-way toll trunks to Purdue University. If a call is for an automatic station, the toll operator as before prefixes the digits *92* to the Purdue station number. If a call is for a manual station, the toll operator dials *90* to signal the Purdue attendant, who completes the call as in manual practice.

Incoming toll calls whether to the attendant or to an automatic station pass over the same group of trunks, through a bi-level repeater in the central office. These trunks operate in a way somewhat similar to that described above for city calls.

Special Features: Conversation Timing

Since there is a tendency for students to engage in long conversations, occupying the telephone when others are waiting to make a call, it was decided to provide a timing feature limiting the length of conversations to six minutes. All calls originating from dormitory lines are restricted in length except calls to the attendant. Since toll calls are handled on a delayed basis, the timing feature does not apply to them.

A conversation timing unit is connected between the linefinder and first selector. The dormitory lines to be timed have been confined to certain levels of the 200-point linefinder banks. The left normal post springs on the linefinder operate on these levels, extending ground over a fourth wire to the conversation timer to start the timing feature. After a predetermined interval (initially five minutes) the persons conversing are warned by a tone over the + line that the connection will be released after one more minute. Sixty seconds later a relay in the conversation timer operates, opening the control lead between the linefinder and first selector, and allowing the switches to release. The timing is done by means of a minor switch in the conversation timing unit which is activated by a one-minute time pulse. The interval may be changed if desired, to allow the maximum of a ten-minute conversation.

Night Blocking of Dormitory Calls

It was believed desirable to limit calls to the dormitories during the night. A *night busy* key has been provided on the attendant's cabinet which, when operated, will block all local calls to the dormitory. Toll calls are not affected by this blocking arrangement. Operation of the *night busy* key opens the leads to the connectors. The first trunk in the group is extended to the attendant and the other trunks are busied back to the selectors. Incoming local calls to the connector groups being busied are intercepted by the attendant. In case of emergency, she may extend the call to the desired station.

Multi-Party Dormitory Lines

The dormitories are served by the twenty-party connectors. A group of students (maximum twenty) is served by one telephone located in a booth in a hall adjoining their sleeping quarters. Ten rooms are included in each group, with one or two students per room. A ringer is located in each room, and when two students occupy the same room a code of one or two rings signals the proper student. When signalled, the student answers the call on the telephone in the hall. With the method provided in most dormitories, it is necessary for someone to answer the telephone and then call the desired individual, thus wasting the time of the person who originally answered. With the system in use in Purdue dormitories, the only one dis-

turbed is the person being called.

A lamp is provided on the telephone in the booth to protect unanswered incoming calls from intrustion by students wishing to make outgoing calls. This lamp remains lighted during the time interval between the bell's ringing in the room and the called person's arrival at the telephone.

Intercepting Incoming City Calls

A special feature has been provided whereby incoming city calls to Purdue stations will be intercepted if the called person does not answer within a predetermined interval. This time interval is two minutes for stations in the twenty-party connector groups and forty seconds for stations in all other connector groups. If the call is not answered within this interval the attendant is signalled by a flashing lamp. When the attendant observes this flash, she intercepts with the answer end of her cord. The called person's telephone meanwhile continues to ring.

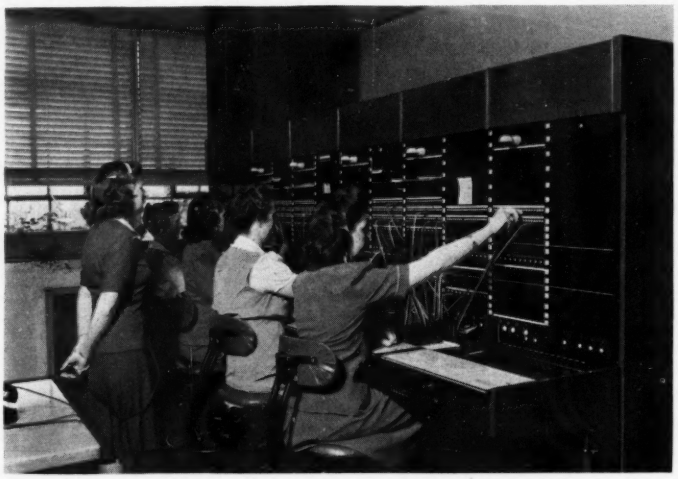

Figure 3. Purdue P-A-B-X attendant's switchboard.

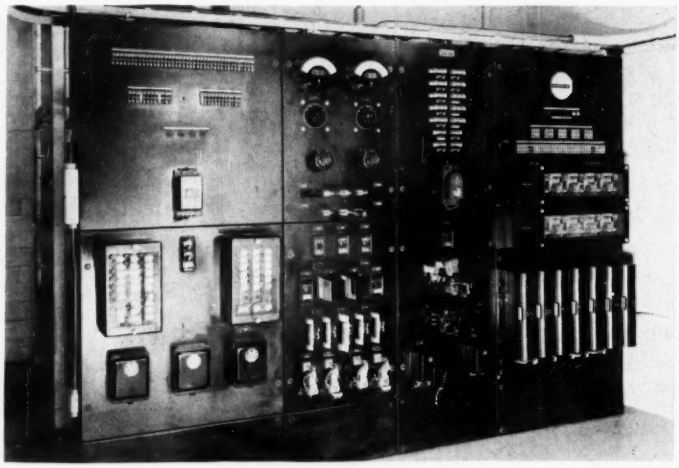

Figure 4. P-A-B-X power panel.

The attendant announces that the called person has failed to answer, and offers to extend the call to someone else, if desired, or gives the individual calling any necessary information. The attendant may, by manipulating a common release key, free the connection to the called person and thus stop the ringing. Calls intercepted by the attendant may be answered at the called station as long as she has not broken down the connection. If someone at the called station does answer, the attendant retires from the connection.

Code Call Facilities

A code call unit was designed to meet the special requirements of the university. It was thought desirable to have the attendant set up and cancel all code call signals instead of providing the standard "Direct Answering and Conversation" type. In

addition, one, two or three sets of codes can be set up and sent out in sequence from the same unit, whereas the standard unit provides for only one set of codes at a time.

A total of five code call units, all of the same type, were provided and connected to the P-A-B-X equipment. Each code call unit is individual to a particular area of the University campus and will supply coded signals to that area only.

Each code call unit is connected to a special second selector level, thereby necessitating a two-digit code prefix to reach any unit. These prefixes are *96, 97, 98, 99,* and *90.*

The code call units for this installation are "special" in that, as mentioned, they provide means whereby one, two, or three sets of codes can be set up and sent out in sequence from the same unit. Likewise, any one set of codes can be cancelled without interfering with the other two codes.

The ultimate capacity of each code call unit is 125 different codes, of which a certain percentage are two-digit and the balance three-digit codes. Initially, four of the units are wired for forty-five codes while one is wired for sixty-five. To increase the capacity up to 125 codes requires only a slight wiring change.

Any P-A-B-X user wishing to have a certain individual paged over the code system calls the attendant by dialing the digit *1.* The attendant accepts the request by recording on a special form the individual to be paged and also the name of the person requesting the call. If desired, she may then dismiss the calling subscriber from the line.

The attendant originates the code call by plugging into a regular outgoing trunk *OGT to P-A-X* with the calling end of a cord, operating the talk key of the cord and the position dialing key. She then dials a four- or five-digit number consisting of the code call unit prefix *96, 97, 98, 99* or *90,* depending upon the area in which the person being paged is located, followed by the two or three digits assigned to the particular code call number of the individual wanted. The attendant then retires from the connection by taking down the cord.

When the person being paged hears his code, he goes to the nearest telephone and calls the attendant by dialing a special number assigned in a PBX connector group. The call is extended to the attendant via her *Trunks from Rotary Connectors.* When she speaks the person gives his name. The attendant knows he is answering a code call because he has dialed the special code answering number. The attendant then checks the list to determine the individual who requested the paging service and advises the person paged of this fact.

In the event that the person who requested the paging service has remained on the connection with the attendant, she connects the two individuals via the cord method at the switchboard. However, if the person who requested paging has hung up, the attendant merely advises the person paged whom to call. The attendant then cancels the code signal by plugging the calling end of another cord into an outgoing trunk *OGT to P-A-X,* and operating the talk key of the cord and the position dialing key. She dials the two prefix digits of the unit over which the code service has been established, following these with the digit *6* and then the two- or three-digit number of the code set up. The extra digit *6* marks the code call unit so that the digits following function to cancel out the code being transmitted.

If one or two additional code signals must be sent out over a particular unit while an existing code is being transmitted, the attendant sets up the codes in the manner previously described and the code call unit functions as before, except that it now sends out the stored codes in sequence. Each of the codes thus established can be cancelled at any time separately by dialing the originally established digits preceded by the additional cancelling digit *6.*

Watchman's Service Equipment

Watchman's service equipment provides a means whereby a supervisor can check the watchman to see that he is reporting from his designated stations in the proper order within the allotted time, and sounds an alarm in case of an irregularity. It enables the supervisor to communicate with the watchman as needed, and in event of an emergency permits sending a distress signal to an outside location.

Watchman's service equipment was provided for five routes of twenty-five stations each. This equipment is reached from levels of the special second selectors by dialing *91, 92, 93, 94, or 95,* depend-

ing upon the route from which he is reporting. A tone indicates to the watchman that his call has been registered and that he may proceed to the next station. Absence of tone means that the supervisor wishes to talk to the watchman and that he should remain on the line until the supervisor speaks.

To eliminate a separate watchman's service turret, the first position of the attendant's cabinet is equipped as a watchman's service position, and is staffed by the supervisor of the watchman's service system.

Conference Equipment

"Meet me" conference equipment has been provided. If it is desired that several persons be connected together on a common circuit, each individual dials *20*. A maximum of ten persons may take part in each such conference.

Intercepting Equipment

Facilities are provided for intercepting all vacant local selector and toll selector levels, all changed and unassigned numbers in the PBX groups, and all changed numbers in the party-line groups.

Numbering Scheme

Purdue telephone numbers consist of four or five digits, depending upon the class of service. These numbers are determined from the variously equipped connector groups, and as certain connector groups provide a particular class of service the assignments are made accordingly. All number groups can be and are used for individual lines. The station numbers and other associated classes of service are as follows:

2100-2199 ..... PBX lines (over 10)
2200-2499 ..... PBX lines (10 or under)
3001-3991; 3002-3992; and so on up to
3000-3990 ..... 5-, 4-, 2-party lines
71001-71991; and so on up to 71000-71990
(one ring) ..... Multi-party (max. 20)
72001-72991; and so on up to 72000-72990
(two rings) ..... Multi-party (max. 20)
81001-81991; and so on up to 81000-81990
(one ring) ..... Multi-party (max. 20)
82001-82991; and so on up to 82000-82900
(two rings) ..... Multi-party (max. 20)

The five-party lines, assigned in the 300 connector group (200-line), consist of four digits as shown above. The first digit, *3*, selects the connector group. The second and third digits determine the connector bank terminal which may be associated with either the first or second hundred group. The fourth and last digit determines the particular hundred group and the frequency of the ringing current supplied to the line—which in turn determines the particular station ringer to be signalled. (Thus between "3000" and "3999" there are two hundred lines, and not one thousand.) If the last digit is between *1* and *5*, ringing current with a frequency of 33, 50, 66, 16 or 25 cycles respectively is supplied to the first hundred group. If the last digit is between *6* and *0*, the same frequencies in the above order are supplied to the second hundred group.

The multi-party lines, assigned in the 700 or 800 connector groups, consist of five digits as shown above. The first digit, *7* or *8*, selects the connector group. The second digit, *1* or *2*, determines whether a one-ring or two-ring signal will be given. The third and fourth digits determine the connector bank or line terminal. The fifth and last digit if between *1* and *5* determines which of the five frequencies will be sent out over the negative side of the line to ground. If between *6* and *0* it determines which of the five frequencies will be sent out over the positive side of the line to ground.

Power Equipment

The power equipment consists of a 26-cell battery including three end cells, two 50-ampere motor generators, two sets of 30-watt ringing generators (one arranged to operate on 220 volts a-c and the other from exchange battery), two sets of harmonic converters for party-line ringing, and associated supervisory and control panels. The rear of the control panels is enclosed by a wire screen providing a finished appearance.

Distributing Frames

Twelve verticals of B-type main distributing frame and nineteen verticals of line and trunk intermediate distributing frame provide for distribution of incoming cables, full line I.D.F. facilities, and distribution of traffic between switch groups.

Purdue University has reason to be proud of its modern and efficient private automatic branch exchange, and Automatic Electric Company is proud to have designed and manufactured the equipment and made the installation. The university's communication facilities now rank among the foremost in the country.

THE AUTOMATIC ELECTRIC "TRAFFICORDER"

By J. E. OSTLINE

***SYNOPSIS:** A newly developed traffic observation device which takes switch counts automatically in the form of a permanent printed record—comparison with "manual" methods—two models of apparatus: Type A observes a maximum of 250 trunks; Type B a maximum of 50 trunks, supplying individual as well as group data—how a Trafficorder observation is conducted.*

IN every well managed telephone exchange traffic observations are made to determine if service and equipment are adequate. Traffic load data may be obtained by various methods and at fixed or irregular intervals. In manual exchanges, for example, where operators' work schedules are determined primarily by the number of calls originated, peg counts are usually taken several times a month. Although holding time of the calls is of lesser significance, supplementary plug counts may occasionally be made to determine average holding times and sufficiency of the equipment (positions, cord circuits and trunks).

In automatic exchanges traffic load data are equally valuable. Traffic registers where provided are in continuous service, recording the number of calls handled in various equipment groups (automatic peg count) as well as traffic congestions and overloads (all trunks busy or overflow meters). Where, however, automatic exchanges do not employ such common devices as register senders, peg count information is of secondary importance. On the other hand, since every call ties up one or more switches (linefinders, selectors, connectors and trunk repeaters) for the whole period of dialing, ringing and talking, *switch usage* is the most important traffic load value in automatic exchanges This figure, including both total calls and holding time of calls, can best be obtained by *switch counts*.

The common switch count method consists of having an observer watch one or more groups or ranks of switches or trunks, counting and recording at fixed regular intervals the number of switches or other equipments in an operated (busy) conditions. Such data are usually taken during the busy hour, and when obtained in sufficient quantities indicate the *average load*. Through simple formulas the *unit calls* carried by an observed group can be ascertained. Once the unit calls are determined, reference to standard traffic tables will show whether the group requires adjustment or is satisfactory for the offered traffic. A complete outline of the foregoing method is given in Circular 1682, "Improving Service Through Switch Counts", published by Automatic Electric Company in 1942.

While this switch count method of obtaining traffic data in dial exchanges offers many advantages over several other systems, some of these advantages cannot be realized fully when the observation is made visually and manually, particularly when many or large switch groups are involved. First, the human element is always a variable factor. Secondly, the effectiveness of this method depends largely on the frequency and regularity of each count or "scanning" period. Hence, especially in large exchanges, many trained observers are required to obtain both quality and quantity information.

In order to exploit the many advantages of the switch count method, Automatic Electric Company has developed an automatic traffic observation unit which utilizes the basic principles of switch counts to the fullest extent, while eliminating the disadvantages of manual observation and recording. This unit automatically "scans" (counts) and instantly records in printed form, at one minute intervals, the number of trunks or equipments busy in each group under observation. At hourly intervals the counts for each trunk group are automatically added and printed. This record contains all the data required to determine immediately the traffic carried by each observed trunk group, either by simple calculations or by the consultation of tables, and without any additional study or interpretation.

Figure 1. Type A Trafficorder (250 trunk capacity).

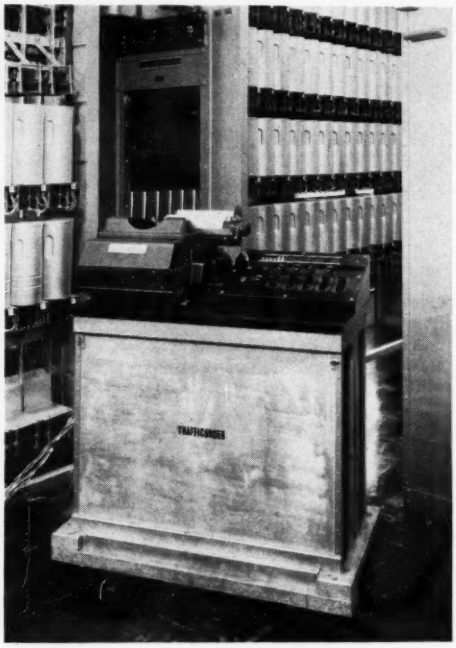

Figure 2. Type B Trafficorder (50 trunk capacity) in operation.

General Description of the Trafficorder

This new piece of apparatus, named the "Trafficorder", is assembled entirely from standard Strowger switching elements, except for the electrically controlled and operated typewriter in the printing mechanism. The principal components—relays and rotary switches—are mounted in a portable cabinet, the top of which forms a table holding the control equipment. Inside one of the door panels is a screw type terminal block to which operating battery and the trunks under observation are jumpered. The record printer can be placed on top of the cabinet, or at a remote point if desired. The cabinet itself is placed in any location facilitating its connection to the equipment under observation.

The Trafficorder is built in two models, Type A and Type B. The operation of each is similar insofar as collection of traffic data is concerned. Though smaller, the Type B unit in addition identifies and records which particular trunks or equipments in each group are occupied (busy) during "scanning".

The Type A Trafficorder has a capacity of 250 trunks, divided into groups as follows:

Grouping 1	25 groups of 10 trucks
Grouping 2	20 groups of 12 trunks
Grouping 3	12 groups of 20 trunks
Grouping 4	10 groups of 25 trunks

The foregoing amounts in each trunk group are maximum, but less than this maximum can be connected in any group. Furthermore, out of the total groups available in any grouping, only as many groups as are required for the observation need be connected. For instance, it may be planned to observe ten groups of connectors with twelve in each group. The Trafficorder would then be set for the "20-12" grouping. The ten remaining groups in this grouping could be used simultaneously, if desired, to observe any other ten trunk groups having any number of trunks each up to twelve. When trunks in groups of more than twenty-five are to be observed, they can be spread over the "10-25" grouping. For example, five groups of forty trunks can use two "10-25" Trafficorder groups for each trunk group. In the final

summary the busy totals for each two Trafficorder groups must then be added together before they are analyzed.

The Type B Trafficorder has a capacity of fifty trunks, divided into groups as follows:

Grouping 1	5 groups of 10 trunks
Grouping 2	3 groups of 16 trunks
Grouping 3	2 groups of 25 trunks
Grouping 4	1 group of 50 trunks

The control (sleeve) lead of each trunk to be observed is jumpered to the Trafficorder terminal block, either directly from the terminal assembly or frame, or through temporary cabling if the Trafficorder is in a remote location. Both manual and automatic trunks can be observed. The scanning circuit is arranged to operate from either positive or negative busy indication on the control (sleeve) lead.

Printing of the clocktime for each observation and the sequence of scanning are controlled by the time motor, a self-contained jacked-in unit. Printing of the various traffic totals on the data sheet depends on the standard Strowger switches and relays, in which are stored the count of each scanning cycle and the grand totals for each hour. Certain "fixed" data connected with each observation, such as the year, month and date, and the actual number of trunks connected in each group for observation, are indicated by means of a simple plugboard. A series of keys controls the selection of desired groupings, the setting of the correct clocktime, and the starting and stopping of observations.

Current to operate the Strowger equipment in the Trafficorder comes from 48-volt exchange battery. Terminals and fuses inside the cabinet provide for suitable jumpered connection to the nearest power panel. An extension cord brings the commercial electric power to the printer and time motor (any standard voltage and frequency) and a desk lamp.

Traffic Observation with Type A Unit

The first step is, of course, to jumper the trunks under observation to the Trafficorder, and similarly connect battery and control leads. The printer is then fitted with a roll of paper and placed on top of the unit. If it is preferred to have the printer at a remote point, jumpering or cabling between it and the unit is required. Control settings are next adjusted as follows: (1) One of the trunk group keys *1* to *4* is operated, depending on the

12	20	47	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
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1	15	00	02	04	05	03	07	06	06	10	10	05	03	02	07	01	01	06	05	04	05	07	09	03	05	03	10
2	15	01	03	04	05	03	04	05	06	06	07	03	06	09	03	02	05	05	07	08	04	05	03	02	01	01	04
3	15	02	04	04	03	03	06	07	05	07	05	07	08	04	05	04	03	05	04	07	02	01	01	04	04	06	06
4	15	03	03	01	01	05	04	02	06	07	05	08	03	04	05	03	02	04	05	03	03	04	02	02	05	10	10
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7	15	06	01	01	02	05	03	02	04	04	03	06	04	07	08	03	04	06	05	02	01	01	03	04	05	05	02
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17	15	16	05	03	06	06	10	10	04	05	10	03	05	10	05	07	08	04	03	05	10	05	10	05	03	04	03
18	15	17	10	05	10	06	03	04	05	06	10	07	04	03	06	06	10	10	04	06	04	03	06	04	05	06	03
19	15	18	05	04	07	08	04	09	03	04	02	02	03	02	04	01	05	07	04	09	06	09	10	10	05	10	06
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21	15	20	05	07	05	03	05	08	06	05	07	05	07	08	04	04	03	01	07	10	10	07	05	08	05	04	06
22	15	21	06	05	03	04	06	03	05	04	01	01	06	07	04	05	03	05	06	08	09	05	04	03	06	03	06
23	15	22	06	05	04	05	07	04	05	03	02	02	05	06	05	03	01	06	07	08	09	05	05	05	03	02	05
24	15	23	05	07	04	03	05	06	04	02	04	03	05	08	01	04	03	05	06	07	03	04	02	05	03	03	04
25	15	24	04	05	03	06	08	04	05	03	02	04	03	03	04	03	01	02	05	04	03	04	03	02	03	04	04
26	15	25	04	03	06	07	05	08	06	07	04	05	03	04	02	04	02	03	01	01	04	04	05	03	06	04	03
27	15	26	04	03	05	03	06	04	05	04	03	04	02	05	06	04	03	06	04	15	06	03	04	05	03	02	02
28	15	27	03	03	04	03	05	04	03	04	02	03	04	05	04	03	05	03	05	01	01	01	04	03	01	01	01
29	15	28	04	05	06	03	04	03	05	04	03	03	04	02	05	03	04	04	05	03	04	03	04	03	04	04	04
30	15	29	06	03	04	02	04	03	05	03	01	01	04	03	01	04	01	02	04	07	05	06	05	04	06	06	04
31	15	30	03	03	05	03	01	01	02	04	05	03	05	04	06	03	05	03	01	01	03	04	08	05	04	06	05
32	15	31	01	01	04	03	06	04	05	04	07	05	04	07	05	07	06	06	05	04	05	06	04	05	04	05	03
33	15	32	03	05	04	05	03	03	03	04	04	02	04	04	01	05	03	08	08	04	09	08	05	07	04	05	03
34	15	33	04	05	03	06	04	07	04	04	03	04	03	05	04	03	04	03	05	04	05	09	05	10	06	07	03
35	15	34	06	05	03	06	05	08	04	04	05	04	06	05	03	03	03	03	05	05	06	08	06	10	10	10	04
36	15	35	10	06	07	08	03	09	05	05	06	05	07	08	05	06	06	06	04	05	04	09	09	06	07	05	03
37	15	36	10	06	05	04	06	07	05	06	04	05	03	02	04	03	05	04	05	06	04	05	03	02	02	04	02
38	15	37	10	10	06	04	05	03	04	05	03	04	03	04	03	05	04	03	05	04	03	04	02	01	01	03	03
39	15	38	05	04	05	03	04	03	02	03	04	03	04	03	02	05	04	06	05	04	02	04	03	04	03	04	02
40	15	39	04	03	05	03	04	05	04	05	04	05	03	03	04	05	01	01	03	02	05	04	02	05	04	07	04
41	15	40	05	04	03	05	03	05	03	04	04	03	02	02	03	02	01	05	04	01	05	04	06	04	07	05	06
42	15	41	08	06	04	05	06	04	06	04	05	03	04	05	03	05	03	04	03	04	05	07	05	07	08	03	05
43	15	42	08	04	05	02	05	04	06	05	07	05	06	06	05	06	05	06	04	06	04	05	04	06	07	07	06
44	15	43	04	05	03	06	04	06	05	06	05	04	07	05	06	04	05	04	05	04	05	03	02	02	02	03	05
45	15	44	05	04	03	02	04	03	04	07	05	06	04	05	04	03	04	03	05	04	06	07	05	06	04	03	06
46	15	45	07	07	05	04	06	05	03	05	04	06	05	06	04	05	04	06	04	07	07	09	06	10	05	04	07
47	15	46	10	10	04	06	10	07	04	10	04	05	05	05	07	07	05	05	06	07	07	09	06	06	07	04	04
48	15	47	10	10	06	10	08	07	05	10	05	05	10	10	03	09	06	08	07	10	10	10	08	10	10	06	07
49	15	48	10	09	10	10	10	10	10	07	06	05	08	03	10	10	10	07	10	10	07	10	08	07	10	10	10
50	15	49	10	05	10	06	10	10	09	09	09	05	06	05	09	03	06	04	04	08	08	09	03	07	09	10	10
51	15	50	10	08	04	06	05	07	06	04	05	03	05	04	06	05	04	05	04	03	06	05	06	07	06	04	07
52	15	51	09	03	05	03	06	04	05	07	05	06	04	06	05	06	07	05	04	05	05	05	05	05	07	04	05
53	15	52	10	10	06	05	06	05	05	07	05	06	04	04	04	05	05	04	05	07	06	06	06	05	07	03	04
54	15	53	07	04	06	03	06	04	05	06	04	05	06	04	07	05	03	04	05	03	04	05	05	05	04	03	04
55	15	54	05	05	04	04	05	03	04	03	05	04	06	04	05	05	05	06	07	04	04	03	03	03	03	03	04
56	15	55	06	05	05	04	05	04	01	01	04	05	04	05	05	07	06	05	06	06	04	05	05	05	05	04	04
57	15	56	06	04	05	02	04	05	03	04	04	03	03	03	04	04	05	05	05	05	06	04	04	05	05	06	05
58	15	57	07	07	06	06	05	04	06	07	04	05	04	06	05	03	04	05	06	05	07	07	05	05	06	06	06
59	15	58	10	10	10	07	05	05	07	05	06	07	07	05	06	06	06	05	05	05	09	10	06	06	05	05	06
60	15	59	10	10	09	06	06	05	05	05	06	06	07	05	05	05	03	04	05	05	09	10	10	05	04	04	05
			3	3	2	2	3	2	3	3	2	2	2	2	2	2	2	2	2	3	3	2	3	2	2	2	
			47	07	95	91	17	98	00	06	95	58	87	76	76	70	44	66	79	89	18	27	93	05	95	80	79

Figure 3. Testrun sample of record produced by Type A Trafficorder (using Grouping 1: 25 groups of 10 trunks each).

grouping used (see above). (2) the actual number of trunks observed in each group is set up on the plug board. (3) The correct date is indicated on the plug board. (4) The clock time is adjusted by means of the "clock setting" keys to show the correct hour and minute. Observations are now begun by moving the start key, and will continue until the start key is restored.

When the start key is operated a line prints itself across the record paper indicating the date and year, followed by trunk group headings from *1* to whatever number of groups is being observed. This is followed by another line showing under each group heading the actual number of trunks connected in each group. These two lines together constitute the "observation heading".

At the end of the first minute (during which the observation heading is printed) another line starts, beginning with the number of the scanning (No. 1) and the clock time. Then under each group heading appears the *number of trunks found busy.* At the end of this cycle, the printer respaces itself to the next line, ready to print the results of scanning No. 2 when the second minute is over. The recording of each scanning cycle continues until scanning No. 60 is reached at the end of one hour.

As soon as it has posted scanning No. 60, the printer records at the bottom of each trunk group column the automatically *added total* of the number of trunks busy during each scanning. As each group total is recorded all associated equipment restores to normal, and the next observation sequence begins.

Traffic Observation with Type B Unit

When the Type B unit is used the observation heading is arranged to provide a separate column for each trunk in each group. Whenever a trunk in the observed group is found busy, that fact will be indicated by a star in the appropriate individual trunk column. To the right of the separate trunk columns is printed a group column, in which the total number of busy trunks in the group is recorded as in the Type A unit.

This additional facility of indicating the particular trunks found busy in each group during each scanning provides data for grading alterations. Such information may lead to changes resulting in improved load carrying capacity of a trunk group without the addition of trunks or other equipments.

When a series of operations has been completed, the record is removed from the printer for analysis. Ways in which these data may be applied are detailed in the circular mentioned above, "Improving Service Through Switch Counts."

The Trafficorder has demonstrated its worth through five years of experimental operation on the West Coast, and forecasts more efficient, more reliable traffic data for forward thinking telephone administrations.